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[XI

ART I

NINETEENTH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

TO THE

SECRETARY OF THE INTERIOR

1897-98

CHARLES D. WALCOTT
DIRECTOR

IN SIX PARTS

PART VI (Continued).—MINERAL RESOURCES OF THE UNITED STATES, 1897
NONMETALLIC PRODUCTS, EXCEPT COAL AND COKE

DAVID T. DAY, CHIEF OF DIVISION

WASHINGTON
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1898

NINETEENTH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

Part VI (Continued).—MINERAL RESOURCES OF THE UNITED STATES, 1897
NONMETALLIC PRODUCTS, EXCEPT COAL AND COKE

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PETROLEUM.[1]

By F. H. OLIPHANT.

[The barrel in this report, unless otherwise specified, is of 42 Winchester gallons.]

IMPORTANT FEATURES FOR THE YEAR.

By a comparison of the tables in this report with those showing the production of petroleum for the preceding year, it will be found that the following features are conspicuous:

First. The total quantity of crude petroleum produced in the United States for the year 1897 is almost identically the same as in 1896.

Second. There was a slight increase in the product of the Appalachian field as a whole, especially in the State of West Virginia.

Third. There was a decided decrease in the production of Lima crude petroleum in the States of Ohio and Indiana.

Fourth. There was a large decrease in the number of wells completed in the Appalachian and in the Lima-Indiana field.

Fifth. There was a comparatively large increase of production in the State of Texas.

Sixth. The stocks increased.

Seventh. The price decreased.

TOTAL PRODUCTION IN THE UNITED STATES.

The entire production of crude petroleum in the United States in 1897 was 60,568,081 barrels, as compared with 60,960,361 barrels in 1896, showing a decrease of 392,280 barrels, a decline of only two-thirds of 1 per cent.

The production for 1896 was the largest of any year in our history; the production of 1897 is next to it; that of 1891 ranked third in quantity, with an output of 54,291,980 barrels.

The following table shows the percentages of the total crude petroleum produced in 1896 and 1897 in the Appalachian, the Lima-

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[1] For much of the statistical information in this report credit should be given to the Oil City Derrick. Other special acknowledgments are given in the body of the report.

Indiana, and all of the remaining fields combined:

Percentages of total crude petroleum produced in the several fields for 1896 and 1897.

Field.	1896.	1897.
	Per cent.	*Per cent.*
Appalachian	55.70	58.19
Lima-Indiana	41.40	37.67
All other	2.90	4.14
Total	100.00	100.00

INCREASE IN THE APPALACHIAN FIELD.

This field includes all of the territory on the northwest flank of the Appalachian Mountains, extending in a general southwesterly direction from southwestern New York, through Pennsylvania, West Virginia, southeastern Ohio, Kentucky, and Tennessee, and terminating in Alabama, although the two States preceding the last named have produced only a small percentage of petroleum and that last named has produced none whatever.

The total production in this field was 35,229,949 barrels in 1897, as compared with 33,970,222 barrels in 1896, showing an increase of 1,259,727 barrels, amounting to 3.71 per cent. The amount and percentage of increase or decrease in this field by States in 1897, as compared with 1896, was as follows:

Production of petroleum in the Appalachian field in 1896 and 1897, by States, showing increase or decrease.

State.	Production.		Increase.	Decrease.	Percentage.	
	1896.	1897.			Increase.	Decrease.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Per cent.*	*Per cent.*
New York	1,205,220	1,279,155	73,935	....	6.13	....
Pennsylvania	19,379,201	17,982,911	....	1,396,290	....	7.20
West Virginia	10,019,770	13,090,045	3,070,275	....	30.64	....
Southeastern Ohio	3,366,031	2,877,838	....	488,193	....	14.50
Total	33,970,222	35,229,949	3,144,210	1,884,483	....	....
Net increase	....	....	1,259,727	....	3.71	....

The production for 1897 was only 609,828 barrels short of the production in 1891, which year gave the largest production in the history of the industry.

DECREASE IN THE LIMA-INDIANA FIELD.

The Lima-Indiana field decreased from 25,255,870 barrels in 1896 to 22,805,033 barrels in 1897, showing a decline of 9.7 per cent. Of this total Ohio furnished, in 1897, 18,682,677 barrels, as compared with 20,575,138 barrels in 1896, a decrease of 9.2 per cent, while Indiana decreased from 4,680,732 barrels in 1896 to 4,122,356 barrels in 1897, a decrease of 11.93 per cent. This field showed an increase of 29.8 per cent in 1896 over 1895.

OTHER STATES.

Colorado increased from 361,450 barrels in 1896 to 477,499 barrels in 1897, a gain of 116,049 barrels, amounting to 32.11 per cent.

California increased from 1,252,777 barrels in 1896 to 1,903,411 barrels in 1897, a gain of 650,634 barrels, amounting to 51.93 per cent.

Texas showed the largest percentage of gain of any of the States yielding petroleum. The production for 1896 was 1,450 barrels, while that of 1897 was 65,975 barrels, an increase of 45½ barrels in 1897 for each one produced in 1896.

Kansas declined from 113,571 barrels in 1896 to 81,098 barrels in 1897, a decrease of 28.59 per cent.

The tables in the body of this report, showing production, value, and percentages of increase and decrease, give additional information in detail.

DECREASE IN THE NUMBER OF WELLS COMPLETED.

There was a large falling off in the number of wells completed in 1897, which represents the field work, as compared with 1896. In the Appalachian field there were 1,752 fewer wells drilled in 1897 than in 1896. In the Ohio-Indiana field there were 2,466 fewer wells drilled in 1897 than in 1896. In both fields together there was a decrease of 4,218 wells in 1897 as compared with 1896, amounting to 31.4 per cent, while the total production in both these fields decreased only 2 per cent in 1897 as compared with 1896.

INCREASE IN STOCKS.

The stocks of crude petroleum in the Appalachian field at the close of 1897 were 11,010,044 barrels, as compared with 9,745,722 barrels at the close of 1896, an increase of 1,264,322 barrels, or 13 per cent.

In the Lima-Indiana field the stocks of crude petroleum at the close of 1897 were 22,939,639 barrels, as compared with 22,573,768 barrels at the close of 1896, a gain of 365,871 barrels, or 1.6 per cent.

The total stocks of the two fields at the close of 1897 were 33,949,683 barrels, as compared with 32,319,490 barrels at the close of 1896, a gain of 1,630,193 barrels, equal to 5 per cent.

Of the total stocks at the close of 1897 the Appalachian field contained 30.8 per cent, the Lima-Indiana, field 69.2 per cent.

DECREASE IN PRICE.

The average price of what has been called certificate or credit-balance oil in the Pennsylvania, New York, Ohio, and West Virginia field in 1897 was 78⅝ cents as compared with $1.17⅞ in 1896, showing a decline of 39¼ cents. The highest average in any single month in 1897 was 90⅓ cents in February. The lowest in November and December was 65 cents for both months.

The average price of northern and southern Lima (Ohio) petroleum was 48 cents in 1897 as compared with 66.7 cents in 1896, a decrease of 18.7 cents.

The average price of Indiana (Lima) petroleum in 1897 was 45½ cents per barrel as compared with 63 cents in 1896, a decrease of 17½ cents.

The total value of the 60,960,361 barrels produced in 1896 was $58,518,709, equal to 96 cents per barrel.

The total value of the 60,568,081 barrels produced in 1897 was $40,929,611, or 67.6 cents per barrel, a decrease of 28.4 cents per barrel, or a decrease in value of $17,589,098.

The natural lubricating oil of Wyoming still continues to command the highest price, as it is quoted at $8 per barrel. Kansas crude petroleum is the lowest, being 40 cents in 1897 as compared with 45 cents in 1896. California petroleum declined 9 cents and Colorado petroleum declined 7½ cents per barrel.

PRODUCTION AND VALUE.

TOTAL PRODUCTION AND VALUE.

In the following table is given a statement of the total amount and the total value of all crude petroleum produced in the United States in 1896 and 1897, by States and important districts:

Total amount and value of crude petroleum produced in the United States in 1896 and 1897.

State and district.	1896.		Average value per barrel.	1897.		Average value per barrel.
	Barrels.	Value.		Barrels.	Value.	
New York	1,205,220	$1,420,653	$1.17⅞	1,279,155	$1,005,736	$0.78⅝
Pennsylvania:						
Pennsylvania	19,327,168	22,781,899	1.17⅞	17,931,631	14,098,745	.78⅝
Franklin	49,329	197,316	4.00	48,880	195,520	4.00
Smith's Ferry	2,704	3,187	1.17⅞	2,400	1,560	.65
Total	19,379,201	22,982,402	1.186	17,982,911	14,295,825	.795
West Virginia:						
West Virginia.. Burning Springs	10,005,966	11,794,532	1.17⅞	13,078,011	10,282,586	.78⅝
Volcano	[a]13,228	33,070	2.50	[a]11,622	26,150	2.25
Petroleum	[b]576	2,016	3.50	[b]412	1,442	3.50
Total	10,019,770	11,829,618	1.18	13,090,045	10,310,178	.7876
Ohio:						
Eastern and southern	3,365,365	3,966,924	1.17⅞	2,877,193	2,262,193	.78⅝
Lima	20,575,138	13,723,617	.667	18,682,677	8,967,685	.48
Mecca-Belden	666	2,897	4.35	645	3,120	4.84
Total	23,941,169	17,693,438	.739	21,560,515	11,232,998	.52
Indiana	4,680,732	2,954,411	.63	4,122,356	1,880,412	.456
Kentucky	1,680	924	.55	322	161	.50
Missouri	43	185	4.30	19	174	9.16
Colorado	361,450	318,977	.88¼	477,499	387,661	.81
California	1,252,777	1,240,990	.99	1,903,411	1,713,102	.90
Texas	1,450	1,050	.72	65,975	37,662	.57
Indian Territory	170	680	4.00	625	2,063	3.30
Illinois	250	1,250	5.00	500	2,000	4.00
Wyoming	2,878	23,024	8.00	3,650	29,200	8.00
Kansas	113,571	51,107	.45	81,098	32,439	.40
Grand total	[c]60,960,361	58,518,709	.96	[d]60,568,081	40,929,611	.676

[a] Production of light oil in Volcano included with West Virginia's product.

[b] Production of light oil in Petroleum included with West Virginia's product.

[c] In addition to this product, 4,325 barrels of crude were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

[d] In addition to this product, 4,377 barrels of crude were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

The increase or decrease of the production of crude petroleum in the several States in 1897 as compared with that in 1896 is shown in the following table:

Amount and percentage of increase or decrease in crude petroleum produced in the several States in 1897 as compared with 1896.

State.	Production.		Percentage.	
	Increase.	Decrease.	Increase.	Decrease.
	Barrels.	*Barrels.*		
New York	73,935		6.13	
Pennsylvania		1,396,290		7.20
West Virginia	3,070,275		30.64	
Ohio		2,380,654		9.94
Indiana		558,376		11.93
Kentucky		1,358		80.83
Missouri		24		55.81
Colorado	116,049		32.11	
California	650,634		51.93	
Texas	64,525		4,450.00	
Indian Territory	455		267.65	
Illinois	250		100.00	
Wyoming	772		26.82	
Kansas		32,473		28.59
Total		392,280		.64

From the above table it will be noticed that the State of West Virginia, by its increase of 30.64 per cent in production in 1897, almost compensated for the decline in Pennsylvania and Ohio. California, Colorado, and Texas show large gains in production.

PRODUCTION BY FIELDS.

The production of petroleum in the principal fields of the United States in 1894, 1895, 1896, and 1897 was as follows:

Production of petroleum in the United States in 1894, 1895, 1896, and 1897, by fields.

[Barrels of 42 gallons.]

Field.	Production.			
	1894.	1895.	1896.	1897.
Appalachian	30,781,924	30,959,139	33,970,222	35,229,949
Lima-Indiana	17,296,510	20,236,741	25,255,870	22,805,033
Florence, Colorado	515,746	438,232	361,450	477,499
Southern California	705,969	1,208,482	1,252,777	1,903,411
Kansas	40,000	44,430	113,571	81,098
Texas	60	50	1,450	65,975
Wyoming	2,369	3,455	2,878	3,650
Other	1,938	1,747	2,143	1,466
Total	49,344,516	52,892,276	[a]60,960,361	[b]60,568,081

[a] In addition to this total, 4,325 barrels of crude oil were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

[b] In addition to this total, 4,377 barrels of crude oil were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES, 1859 TO 1897.

In the following table will be found a statement of the production of crude petroleum in the United States from the beginning of production, marked by the drilling of the Colonel Drake well in 1859, up to and including the production of 1897, the tables being by years and States:

Production of crude petroleum in the United States from 1859 to 1897.

[Barrels.]

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	Colorado.	California.	Indiana.
1859...	2,000	....	....	....	....	....
1860...	500,000	....	....	....	....	....
1861...	2,113,609	....	....	....	....	....
1862...	3,056,690	....	....	....	....	....
1863...	2,611,309	....	....	....	....	....
1864...	2,116,109	....	....	....	....	....
1865...	2,497,700	....	....	....	....	....
1866...	3,597,700	....	....	....	....	....
1867...	3,347,300	....	....	....	....	....
1868...	3,646,117	....	....	....	....	....
1869...	4,215,000	....	....	....	....	....
1870...	5,260,745	....	....	....	....	....
1871...	5,205,234	....	....	....	....	....
1872...	6,293,194	....	....	....	....	....
1873...	9,893,786	....	....	....	....	....
1874...	10,926,945	....	....	....	....	....
1875...	8,787,514	[a] 200,000	[a] 3,000,000	....	[a] 175,000	....
1876...	8,968,906	31,763	120,000	....	12,000	....
1877...	13,135,475	29,888	172,000	....	13,000	....
1878...	15,163,462	38,179	180,000	....	15,227	....
1879...	19,685,176	29,112	180,000	....	19,858	....
1880...	26,027,631	38,940	179,000	....	40,552	....
1881...	27,376,509	33,867	151,000	....	99,862	....
1882...	30,053,500	39,761	128,000	....	128,636	....
1883...	23,128,389	47,632	126,000	....	142,857	....
1884...	23,772,209	90,081	90,000	....	262,000	....
1885...	20,776,041	661,580	91,000	....	325,000	....
1886...	25,798,000	1,782,970	102,000	....	377,145	....
1887...	22,356,193	5,022,632	145,000	76,295	678,572	....
1888...	16,488,668	10,010,868	119,448	297,612	690,333	....
1889...	21,487,435	12,471,466	544,113	316,476	303,220	33,375
1890...	28,458,208	16,124,656	492,578	368,842	307,360	63,496

[a] Including all production prior to 1876.

Production of crude petroleum in the United States from 1859 to 1897—Continued.

[Barrels.]

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	Colorado.	California.	Indiana.
1891...	33,009,236	17,740,301	2,406,218	665,482	323,600	136,634
1892...	28,422,377	16,362,921	3,810,086	824,000	385,049	698,068
1893...	20,314,513	16,249,769	8,445,412	594,390	470,179	2,335,293
1894...	19,019,990	16,792,154	8,577,624	515,746	705,969	3,688,666
1895...	19,144,390	19,545,233	8,120,125	438,232	1,208,482	4,386,132
1896...	20,584,421	23,941,169	10,019,770	361,450	1,252,777	4,680,732
1897...	19,262,066	21,560,515	13,090,045	477,499	1,903,411	4,122,356
Total.	556,503,747	178,845,457	60,289,419	4,936,024	9,840,089	20,144,752

Year.	Kentucky and Tennessee.	Illinois.	Kansas.	Texas.	Missouri.	Indian Territory.	Wyoming.	United States.
1859....	....	......	....	......	......	......	....	2,000
1860....	....	......	....	......	......	......	....	500,000
1861....	....	......	....	......	......	......	....	2,113,609
1862....	....	......	....	......	......	......	....	a3,056,690
1863....	....	......	....	......	......	......	....	2,611,309
1864....	....	......	....	......	......	......	....	2,116,109
1865....	....	......	....	......	......	......	....	2,497,700
1866....	....	......	....	......	......	......	....	3,597,700
1867....	....	......	....	......	......	......	....	3,347,300
1868....	....	......	....	......	......	......	....	3,646,117
1869....	....	......	....	......	......	......	....	4,215,000
1870....	....	......	....	......	......	......	....	5,260,745
1871....	....	......	....	......	......	......	....	5,205,234
1872....	....	......	....	......	......	......	....	6,293,194
1873....	....	......	....	......	......	......	....	9,893,786
1874....	....	......	....	......	......	......	....	10,926,945
1875....	....	......	....	......	......	......	....	b12,162,514
1876....	....	......	....	......	......	......	....	9,132,669
1877....	....	......	....	......	......	......	....	13,350,363
1878....	....	......	....	......	......	......	....	15,396,868
1879....	....	......	....	......	......	......	....	19,914,146
1880....	....	......	....	......	......	......	....	26,286,123
1881....	....	......	....	......	......	......	....	27,661,238
1882....	c160,933	......	....	......	......	......	....	30,510,830

[a] In addition to this amount, it is estimated that for want of a market some 10,000,000 barrels ran to waste in and prior to 1862 from the Pennsylvania fields; also a large amount from West Virginia and Tennessee.

[b] Including all production prior to 1876 in Ohio, West Virginia, and California.

[c] This includes all the petroleum produced in Kentucky and Tennessee prior to 1883.

Production of crude petroleum in the United States from 1859 to 1897—Continued.

[Barrels.]

Year.	Kentucky and Tennessee.	Illinois.	Kansas.	Texas.	Missouri.	Indian Territory.	Wyoming.	United States.
1883....	4,755	......	....	......	......	......	....	23,449,633
1884....	4,148	......	....	......	......	......	....	24,218,438
1885....	5,164	......	....	......	......	......	....	21,858,785
1886....	4,726	......	....	......	......	......	....	28,064,841
1887....	4,791	......	....	......	......	......	....	28,283,483
1888....	5,096	......	....	......	......	......	....	27,612,025
1889....	5,400	1,460	500	48	20	......	....	35,163,513
1890....	6,000	......	1,200	54	278	......	....	45,822,672
1891....	9,000	......	1,400	54	25	30	....	54,291,980
1892....	6,500	......	....	45	10	80	....	50,509,136
1893....	3,000	......	....	50	50	10	....	48,412,666
1894....	1,500	300	40,000	60	8	130	2,369	49,344,516
1895....	1,500	200	44,430	50	10	37	3,455	52,892,276
1896....	[a] 1,680	250	113,571	1,450	43	170	2,878	[a] 60,960,361
1897....	[a] 322	500	81,098	65,975	19	625	3,650	[a] 60,568,081
Total.	224,515	2,710	282,199	67,786	463	1,082	12,352	831,150,595

[a] In addition to this amount, 4,325 barrels of crude oil were produced in Kentucky and Tennessee in 1896 and 4,377 barrels in 1897, for which, as none was sold or used, no value could be given.

From the above table it appears that the enormous amount of 831,150,595 barrels, or 105,542,933 metric tons, of crude petroleum has been taken out of the rocks in the United States since Colonel Drake drilled the first oil well in 1859, near Titusville, Pennsylvania. If we allow 5.6 cubic feet to one barrel of petroleum this would amount to 4,654,443,332 cubic feet. The sides of a cube to contain this would be 1,669.5 feet long. It would fill a hoop containing about 36 square feet, or a pipe line 6.9 feet in diameter, extending entirely around the earth. If we take the surface of Lake Erie to be 10,000 square miles it would cover it to a depth of 0.2 of an inch, or it would fill a reservoir having an area of 1 square mile and a depth of 167 feet.

For convenience of reference, a statement is given below of the production of petroleum in the United States from 1892 to 1897, by States:

Production of petroleum in the United States from 1892 to 1897.

[Barrels of 42 gallons.]

State.	1892.	1893.	1894.	1895.	1896.	1897.
Pennsylvania and New York	28,422,377	20,314,513	19,019,990	19,144,390	20,584,421	19,262,066
Ohio	16,362,921	16,249,769	16,792,154	19,545,233	23,941,169	21,560,515
West Virginia	3,810,086	8,445,412	8,577,624	8,120,125	10,019,770	13,090,045
Colorado	824,000	594,390	515,746	438,232	361,450	477,499
California	385,049	470,179	705,969	1,208,482	1,252,777	1,903,411
Indiana	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,122,356
Kentucky	6,500	3,000	1,500	1,500	1,680	322
Illinois			300	200	250	500
Kansas			40,000	44,430	113,571	81,098
Texas	45	50	60	50	1,450	65,975
Missouri	10	50	8	10	43	19
Indian Territory	80	10	130	37	170	625
Wyoming			2,369	3,455	2,878	3,650
Total	50,509,136	48,412,666	49,344,516	52,892,276	[a] 60,960,361	[a] 60,568,081

[a] In addition to this amount, 4,325 barrels of crude oil were produced in Kentucky and Tennessee in 1896 and 4,377 barrels in 1897, for which, as none was sold or used, no value could be given.

EXPORTS.

In the following table are given the exports of crude petroleum and its products from the United States from 1871 to 1897, together with a statement of the production of the United States in the years named. The figures of exports are from the Statistical Abstract of the United States, published by the Bureau of Statistics, Treasury Department. The figures of production were collected by the writer and other agents of the Geological Survey.

Quantity of crude petroleum produced in, and the quantities and values of petroleum products exported from, the United States during each of the calendar years from 1871 to 1897.

Year ending December 31—	Production.		Exports.											
	Barrels (of 42 gallons).	Gallons.	Mineral, crude (including all natural oils, without regard to gravity).		Mineral, refined or manufactured.		Mineral, refined or manufactured.				Residuum (tar, pitch, and all other, from which the light bodies have been distilled).		Total.	
					Naphthas, benzine, gasoline, etc.		Illuminating.		Lubricating (heavy paraffin, etc.).					
			Gallons.	*Dollars.*	*Gallons.*	*Dollars.*	*Gallons.*	*Dollars.*	*Gallons.*	*Dollars.*	*Gallons.*	*Dollars.*	*Gallons.*	*Dollars.*
1871....	5,205,234	218,619,828	11,278,589	2,171,706	8,396,905	895,910	132,178,843	33,493,351	240,228	92,408	101,052	10,450	152,195,617	36,663,825
1872....	6,293,194	264,314,148	16,363,975	2,761,094	8,688,257	1,307,058	118,259,832	29,456,453	438,425	180,462	568,218	56,618	144,318.707	33.761,685
1873....	9,893,786	415,539,012	19,643,740	2,665,171	10,250,497	1,266,962	207,595,988	41,857,686	1,502,503	517,466	1,377,180	117,595	240,369,908	45,921,880
1874....	10,926,945	458,931,690	14,430,851	1,428 494	10,616,644	997,355	206,562,977	30,168,747	993,068	269,886	2,504,628	177,794	235,108,168	33,042,276
1875....	12,162,514	510,825,588	16,536,800	1.738,589	14,048,726	1,392,192	203,678,748	28,168,572	938,052	265,837	2,323,986	169,671	237,526,312	31,734,861
1876....	9,132,669	383,572,098	25,343,271	3,343,763	13,252,751	1,502,498	220,831,608	44,089,066	1,157,929	370,431	2,863,896	239,461	263,449,455	49,545,219
1877....	13,350,363	560,715,246	28,773,233	3,267,309	19,565,909	1,938,672	307,373,842	51,366,205	1,914,129	577,610	4,256,112	390,077	361,883.225	57,539,873
1878....	15,396,868	646,668,456	24,049,604	2,169,790	13,431,782	1,077,402	306,212,506	36,855,798	2,525,545	698,182	3,126,816	220,835	349,346,253	41,022,007
1879....	19,914,146	836,394,132	28,601,650	2,069,458	19,524,582	1,367,996	365,597,467	32,811,755	3,168,561	713,208	4,827,522	273,050	421,719,782	37.235,467
1880....	26,286,123	1,104,017,166	36,748,116	2,772,400	15,115,131	1,344,529	286,131,557	29,047,908	5,607,009	1,141,825	3,177,630	198,983	346,779,443	34,505,645
1881....	27,661,238	1,161,771,996	40,430,108	3,089,297	20,655,116	1,981,197	444,666,615	42,122,683	5.053,862	1,165,605	3,756,018	197,321	514,561.719	48,556,103
1882....	30,510,830	1,281,454,860	45,011,154	3,373,302	16,969,839	1,304,041	428,424,581	37.635,981	8,821,536	2,034,487	4,265,352	275,263	503,492,462	44,623,074
1883....	23,449,633	984,884,586	59,018,537	4,439,097	17,365,314	1,195,035	440,150,660	39,470.352	10,108,394	2,193,245	6,502,524	465,350	533,145,429	47,763,079
1884....	24,218,438	1,017,174,396	79,679,395	6,102,810	13,676,421	1,132,528	433,851,275	39,450,794	11,985,219	2,443,385	5,303,298	327,599	544,495,608	49,457,116
1885....	21,858,785	918,068,970	81,435,609	6,040,685	14,739,469	1.160,999	445,880,518	39,476,082	12,978,955	2,659,210	5,713,908	334,767	560,784,459	49,671,743
1886....	28,064,841	1,178,723,322	76,346,480	5,068,409	14,474,951	1,264,736	485,120,680	39,012,922	13,948,367	2,689,464	1,993,824	109,673	591,884.302	48,145,204
1887....	28,283,483	1,187,906,286	80,650,286	5,141,833	12,382,213	1,049,043	485,242.107	37,007,336	20,582,613	3,559,280	2,989,098	141,350	601,846,317	46,898,842
1888....	27,612,025	1,159,705,050	77,549,452	5,454,705	13,481,706	1,083,429	455,045,784	37,236,111	24,510,437	4,215,449	1,870,596	116,009	572,457,975	48,105,703
1889....	35,163,513	1,476,867,546	85,189,658	6,134,002	13,984,407	1,208,116	551,769,666	41,215,192	27,903,267	4,638,724	1,858,458	97,265	680,705,456	53,293,299
1890....	45,822,672	1,924,552,224	96,572,625	6,535,499	12,462,636	1,050,613	550,873,438	39,826,086	32,090,537	4,766,850	1,830,612	91,905	693,829,848	52,270,953
1891....	54,291,980	2,280,263,160	96,722,807	5,365,579	11,424,993	868,137	531,445,099	34,879,759	33,310,264	4,999,978	1,002,414	61,382	673,905,577	46,174,835
1892....	50,509,136	2,121,383,712	104,397,107	4,696,191	16,393,284	1,037,558	589,418,185	31,826,545	34,026,855	5,130,643	403,032	38,220	744,638,463	42,729,157
1893 *a* ..	48,412,666	2,033,331,972	111,703,508	4,567,391	17,304,005	1,074,710	642,239,816	31,719,404	32,432,857	4,738,892	541,044	41,661	804,221,230	42,142,058
1894....	49,344,516	2,072,469.672	121,926,349	4,415,915	15,555,754	943,970	730,368,626	30,676,217	40,190,577	5,449,000	211,008	14,704	908,252,314	41,499,806
1895....	52,892,276	2,221,475,592	111.285,264	5,161,710	14,801,224	910,988	714,859,144	34,706,844	43,418,942	5,867,477	137,508	13,063	864,502,082	46,660,082
1896....	*b* 60,960,361	2,560,335,162	110,923,620	6,121,836	12,349,319	1,059,542	716,455,565	48,630,920	50,525,530	6,556,775	204,960	14,330	890,458,994	62,383,403
1897....	*b* 60,568,081	2,543,859,402	131,726,243	6,171,852	14,249,028	1,123,347	771,350,626	48,343,916	50,199,345	6,619,864	5,989,704	176,058	973,514,946	62,635,037

a Exports are for fiscal years since 1893. *b* In addition to this amount, 4,325 barrels of crude oil were produced in Kentucky and Tennessee in 1896, and 4,377 barrels in 1897, for which, as none was sold or used, no value could be given.

FOREIGN MARKETS.

In the following table is given a statement showing the foreign markets for our oil in the past eight years. As will be seen from this table, the total exports of illuminating oils have increased.

Exports of petroleum in its various forms from the United States from 1890 to 1897, by countries.

Country.	1890.	1891.	1892.	1893.
CRUDE.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
France	68, 947, 436	61, 663, 973	69, 100, 657	69, 424, 609
Germany	1, 188, 266	3, 107, 137	5, 247, 209	4, 182, 963
Spain	13, 934, 088	17, 103, 416	17, 064, 929	21, 112, 042
United Kingdom	....	....	....	....
Other Europe	3, 680, 631	2, 380, 600	1, 935, 014	3, 948, 842
Total	87, 750, 421	84, 255, 126	93, 347, 809	98, 668, 456
North America:				
Mexico	2, 217, 846	3, 854, 176	3, 499, 514	5, 508, 769
Cuba	4, 913, 330	3, 300, 455	6, 316, 406	6, 955, 315
Other North America	36, 806	4, 338	425, 348	548, 068
Total	7, 167, 982	7, 158, 969	10, 241, 268	13, 012, 152
All other countries	532, 250	1, 000	3, 690	22, 900
Total crude	95, 450, 653	91, 415, 095	103, 592, 767	111, 703, 508
REFINED.				
Naphthas.				
Europe:				
France	4, 195, 704	2, 831, 929	1, 561, 284	4, 080, 839
Germany	2, 015, 298	3, 227, 106	3, 471, 652	4, 127, 354
United Kingdom	5, 603, 994	5, 058, 325	6, 813, 416	8, 209, 526
Other Europe	928, 616	824, 537	686, 398	658, 270
Total	12, 743, 612	11, 941, 897	12, 532, 750	17, 076, 989
North America	59, 563	86, 910	35, 762	122, 237
South America	78, 180	71, 192	89, 609	55, 940
Asia and Oceanica	45, 214	55, 005	57, 787	39, 625
Africa	10, 864	16, 143	12, 070	9, 214
Total	193, 821	229, 250	195, 228	227, 016
Total naphthas	12, 937, 433	12, 171, 147	12, 727, 978	17, 304, 005

Exports of petroleum in its various forms from the United States from 1890 to 1897, by countries—Continued.

Country.	1890.	1891.	1892.	1893.
REFINED—continued.				
Illuminating.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium	41, 391, 323	32, 397, 015	31, 471, 121	33, 541, 439
Denmark	7, 147, 115	9, 135, 043	7, 019, 575	12, 262, 308
France	2, 088, 291	3, 764, 974	3, 005, 535	8, 161, 023
Germany	140, 264, 082	162, 187, 071	133, 417, 314	119, 277, 484
Italy	19, 747, 758	20, 955, 728	22, 324, 113	22, 815, 279
Netherlands	47, 315, 526	54, 879, 032	76, 607, 780	51, 298, 480
Sweden and Norway	11, 772, 106	8, 957, 350	11, 159, 824	16, 312, 922
United Kingdom	66, 393, 246	81, 028, 529	94, 901, 777	180, 996, 321
Other Europe	7, 464, 013	8, 759, 531	6, 450, 040	8, 654, 660
Total	343, 583, 460	382, 064, 273	386, 357, 079	453, 319, 916
North America:				
British North America	5, 104, 864	5, 230, 259	5, 735, 411	6, 341, 042
West Indies	4, 404, 548	3, 303, 506	4, 262, 935	4, 439, 118
Other North America	2, 520, 131	3, 303, 608	2, 250, 162	2, 204, 602
Total	12, 029, 543	11, 837, 373	12, 248, 508	12, 984, 762
South America:				
Argentina	3, 113, 750	3, 476, 192	4, 825, 196	4, 070, 719
Brazil	8, 695, 291	10, 470, 656	14, 028, 476	15, 556, 685
Uruguay	3, 492, 158	3, 165, 880	4, 293, 400	2, 882, 105
Other South America	6, 236, 596	4, 792, 161	6, 827, 814	6, 041, 571
Total	21, 537, 795	21, 904, 889	29, 974, 886	28, 551, 080
Asia and Oceanica:				
China	13, 072, 000	27, 160, 660	17, 370, 600	27, 874, 230
Hongkong	11, 150, 220	10, 814, 630	16, 529, 790	12, 758, 820
East Indies	63, 456, 071	63, 285, 770	55, 907, 410	57, 404, 175
Japan	37, 892, 930	31, 000, 629	23, 761, 930	26, 869, 510
British Australasia	7, 976, 572	10, 276, 095	10, 376, 260	11, 053, 991
Other Asia and Oceanica	3, 982, 465	4, 630, 690	3, 095, 516	2, 637, 250
Total	137, 530, 258	147, 168, 474	127, 041, 536	138, 597, 976
Africa	8, 426, 714	8, 058, 806	8, 865, 999	8, 206, 932
All other countries	187, 320	85, 990	408, 650	579, 150
Total illuminating	523, 295, 090	571, 119, 805	564, 896, 658	642, 239, 816

Exports of petroleum in its various forms from the United States from 1890 to 1897, by countries—Continued.

Country.	1890.	1891.	1892.	1893.
REFINED—continued.				
Lubricating.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium	1, 955, 145	2, 337, 030	2, 632, 954	2, 426, 926
France	3, 088, 183	3, 948, 257	2, 461, 722	2, 426, 659
Germany	3, 670, 937	4, 186, 225	4, 512, 639	3, 798, 953
Italy	510, 622	591, 996	404, 971	788, 805
Netherlands	2, 037, 437	1, 504, 623	2, 229, 116	1, 842, 608
United Kingdom	17, 035, 447	18, 767, 573	18, 779, 806	17, 683, 132
Other Europe	146, 557	111, 165	209, 713	249, 474
Total	28, 444, 328	31, 446, 869	31, 240, 921	29, 216, 557
North America	524, 898	570, 380	656, 991	1, 043, 770
South America	721, 669	889, 610	798, 194	1, 207, 232
Asia and Oceanica	457, 363	582, 392	813, 618	888, 032
Africa	14, 264	25, 479	81, 352	77, 266
Total	1, 718, 194	2, 067, 861	2, 350, 155	3, 216, 300
Total lubricating	30, 162, 522	33, 514, 730	33, 591, 076	32, 432, 857
Residuum (barrels).				
Europe	10, 017	9, 058	6, 361	10, 404
North America	42, 141	28, 833	6, 622	2, 202
All other countries	758	175	287	276
Total residuum	52, 916	38, 066	13, 270	12, 882

Exports of petroleum in its various forms from the United States from 1890 to 1897, by countries—Continued.

Country.	1894.	1895.	1896.	1897.
CRUDE.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
France	84, 434, 953	72, 802, 459	79, 242, 152	100, 153, 929
Germany	4, 877, 593	3, 966, 870	817, 212	2, 430, 249
Netherlands	....	....	4, 455, 469	2, 400, 000
Spain	15, 176, 034	15, 188, 547	12, 869, 235	12, 049, 778
United Kingdom	....	3, 997, 013	....	....
Other Europe	2, 009, 727	2, 590, 441	1, 212, 528	1, 345, 360
Total	106, 498, 307	98, 545, 330	98, 596, 596	118, 379, 316
North America:				
Mexico	8, 026, 189	5, 229, 983	6, 779, 059	7, 090, 850
Cuba	6, 865, 549	6, 980, 372	4, 838, 657	4, 772, 589
Other North America	534, 304	523, 579	708, 008	623, 958
Total	15, 426, 042	12, 733, 934	12, 325, 724	12, 487, 397
South America:				
Brazil	....	....	....	841, 140
Total	....	....	....	841, 140
All other countries	2, 000	6, 000	1, 300	18, 390
Total crude	121, 926, 349	111, 285, 264	110, 923, 620	131, 726, 243
REFINED.				
Naphthas.				
Europe:				
France	3, 764, 569	1, 564, 360	1, 672, 056	2, 103, 725
Germany	4, 278, 757	4, 900, 028	2, 814, 217	2, 800, 883
Netherlands	....	....	....	1, 400, 000
United Kingdom	6, 834, 760	7, 343, 355	7, 236, 285	7, 125, 371
Other Europe	364, 135	577, 378	160, 658	281, 541
Total	15, 242, 221	14, 385, 121	11, 883, 216	13, 711, 520
North America	106, 454	145, 970	208, 249	256, 869
West Indies	67, 195	84, 299	104, 062	83, 529
South America	79, 777	135, 752	96, 020	67, 178
Asia and Oceanica	57, 057	45, 217	49, 927	120, 479
Africa	3, 050	4, 865	7, 845	9, 453
Total	313, 533	416, 103	466, 103	537, 508
Total naphthas	15, 555, 754	14, 801, 224	12, 349, 319	14, 249, 028

Exports of petroleum in its various forms from the United States from 1890 to 1897, by countries—Continued.

Country.	1894.	1895.	1896.	1897.
REFINED—continued.				
Illuminating.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium	36, 312, 974	35, 385, 765	35, 413, 132	42, 437, 133
Denmark	9, 290, 251	14, 626, 436	12, 693, 927	14, 001, 755
France	11, 812, 001	6, 204, 663	5, 338, 501	2, 736, 190
Germany	86, 388, 785	100, 829, 413	121, 841, 266	114, 583, 356
Italy	22, 945, 037	28, 017, 572	22, 648, 184	24, 525, 066
Netherlands	31, 868, 189	45, 900, 640	122, 510, 644	126, 341, 441
Sweden and Norway	9, 848, 074	24, 623, 246	10, 582, 677	18, 961, 261
United Kingdom	274, 555, 010	279, 064, 424	181, 883, 052	185, 200, 507
Other Europe	7, 232, 024	6, 586, 826	8, 149, 109	7, 870, 994
Total	490, 252, 345	541, 238, 985	521, 060, 492	536, 657, 703
North America:				
British North America	8, 218, 417	7, 621, 352	9, 534, 590	9, 522, 282
West Indies	4, 174, 856	4, 109, 358	4, 689, 128	4, 650, 470
Other North America	1, 759, 565	1, 501, 157	1, 493, 040	1, 379, 462
Total	14, 182, 838	13, 231, 867	15, 716, 758	15, 552, 214
South America:				
Argentina	3, 162, 846	5, 876, 742	7, 803, 218	9, 703, 792
Brazil	12, 154, 709	15, 315, 196	18, 490, 043	19, 819, 941
Chile	....	....	4, 325, 915	3, 622, 300
Uruguay	2, 520, 571	3, 898, 514	3, 622, 810	2, 821, 420
Other South America	5, 503, 680	7, 245, 123	4, 267, 282	4, 505, 965
Total	23, 341, 806	32, 335, 575	38, 509, 268	40, 473, 418
Asia and Oceanica:				
China	40, 377, 296	18, 022, 800	25, 694, 890	42, 516, 120
Hongkong	16, 888, 820	10, 595, 610	10, 499, 000	14, 977, 050
East Indies	85, 907, 557	46, 680, 054	43, 706, 780	45, 980, 260
Japan	37, 272, 450	24, 298, 170	33, 701, 038	46, 252, 501
British Australasia	11, 821, 881	14, 686, 752	13, 721, 827	15, 329, 222
Other Asia and Oceanica	2, 944, 958	3, 636, 230	3, 131, 405	3, 722, 800
Total	195, 212, 962	117, 919, 616	130, 454, 940	168, 777, 953
Africa	7, 049, 455	9, 676, 741	10, 280, 607	9, 988, 338
All other countries	329, 220	456, 360	433, 500	571, 000
Total illuminating	730, 368, 626	714, 859, 144	716, 455, 565	772, 020, 626

Exports of petroleum in its various forms from the United States from 1890 to 1897, by countries—Continued.

Country.	1894.	1895.	1896.	1897.
REFINED—continued.				
Lubricating.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium	2, 931, 204	2, 679, 832	4, 078, 951	3, 784, 941
France	3, 050, 547	3, 271, 804	5, 165, 586	4, 225, 199
Germany	5, 637, 471	5, 378, 398	5, 990, 561	6, 877, 196
Italy	1, 356, 340	1, 381, 587	1, 324, 994	1, 550, 688
Netherlands	2, 346, 896	2, 641, 209	2, 724, 546	2, 840, 832
United Kingdom	19, 668, 767	21, 209, 497	23, 436, 081	21, 301, 290
Other Europe	415, 385	520, 025	815, 017	1, 011, 201
Total	35, 406, 610	37, 082, 352	43, 535, 736	41, 591, 347
North America	1, 308, 586	1, 248, 751	1, 244, 538	1, 259, 249
West Indies	417, 123	316, 274	213, 301	114, 942
South America	1, 509, 708	2, 159, 844	2, 221, 780	1, 876, 794
Asia and Oceanica	1, 433, 191	2, 438, 975	3, 000, 471	4, 879, 886
Africa	115, 359	172, 746	309, 701	477, 127
Total	4, 783, 967	6, 336, 590	6, 989, 794	8, 607, 998
Total lubricating	40, 190, 577	43, 418, 942	50, 525, 530	50, 199, 345
Residuum (barrels).				
Europe	2, 056	2, 099	4, 248	140, 777
North America	2, 460	1, 045	438	566
All other countries	513	130	194	1, 269
Total residuum	5, 029	3, 274	4, 880	142, 612

PRODUCTION BY FIELDS, STATES, AND DISTRICTS.

The detailed results of operations in the Appalachian oil field in 1897 by States, fields, and districts, and in the Lima-Indiana field, are here presented. As the State of Ohio contains a part of both fields, that part outside of the southeastern district is discussed in connection with the latter.

APPALACHIAN OIL FIELD.

NEW YORK.

In the Allegany field there was a considerable extension of the Alma and Bolivar pools.

There was a production of 771,606 barrels in 1897, as compared with 736,606 barrels in 1896. There were 350 wells completed in 1897, as compared with 331 wells completed in 1896. The initial daily production of these wells in 1897 was 1,332 barrels as compared with 1,742 barrels in 1896. The manner in which the older wells held up their production accounts for the increase in production.

The Bradford field derives a portion of its oil from Cattaraugus County, New York, its northern extension.

It is estimated that the total production of the portion of this field outside of Pennsylvania is equal to about 13 per cent of the entire production of the Bradford field, making 507,549 barrels produced in this portion in 1897.

The total production for the State in 1897 was 1,279,155 barrels, valued at 78⅝ cents per barrel, as compared with 1,205,220 barrels, valued at $1.17⅞ per barrel in 1896.

PENNSYLVANIA.

The Bradford district.—The old Bradford field, which includes a portion of New York and northeastern McKean County, continues to be fairly good stripping, with occasionally a fair well on the edges of the older developments, caused in some instances by the flooding of the oil rock with water. No field so far developed in all the Appalachian field possessed the universal productiveness over so large an area that this one did when first developed.

The total production of the Bradford field in 1897 was 3,904,230 barrels, as compared with 3,604,771 barrels in 1896, an increase of 299,459 barrels, although there were only 696 wells completed in 1897, as compared with 769 in 1896, a decrease of 73 wells.

The initial daily production in 1897 was 7,037 barrels, as compared with 9,462 in 1896. The number of dry holes drilled in 1897 was 114, as compared with 78 in 1896.

The Ormsby field continued to produce some good wells, but a good part of the production throughout the field was increased by the more careful manipulations of the producing wells, aided by improved pumping appliances in which the gas engine, in connection with compressed air, is an important adjunct.

The Warren and Forest County district.—This district includes the production in southwestern McKean County, eastern and southeastern Warren County, northwestern Elk County, and northeastern Forest County. It has been subdivided into the Tiona pool, Warren and Clarendon pool, and the Middle pool or district. The production of the Warren and Forest County district in 1897 was 1,999,108 barrels, as compared with 1,650,936 barrels in 1896, a gain of 348,172 barrels. The Watsonville pool furnished the bulk of this increased production, as there were quite a number of good wells found in this pool in the early part of 1897. The first well to develop the producing quality of this pool was completed by Messrs. Mallory & Company, of Bradford, August 1, 1896. During the early part of 1897 many large wells were obtained.

The general outline of the pool has been determined to be nearly 1 mile wide and to extend in a northeastern direction for 3 miles. The oil is found in a white pebble sand from 3 to 15 feet in thickness, which is found at a depth of from 1,440 to 1,460 feet at Watsonville and corresponds to the Kinzua sand. The wells originally all flowed and were undisturbed by nitro-glycerine. The Bradford sand was found to contain some indications of oil at about 1,900 feet or 500 feet below the Watsonville sand. The gravity of this oil is 46.5° Baumé. It is surprising that this prolific field should remain undiscovered so many years, as it is only 5 to 6 miles southwest of the southern development of the old Bradford field. In the general effort to extend the latter there are a number of instances on record where a whole section has been condemned because of its nearness to old developed territory. A careful reconnaissance of the ground may reveal ample room for such occurrences. Outside of this pool no fresh territory was found, and the business for the year settled down to the economical pumping of the old wells.

The Lower district.—This includes the southwestern portion of Warren County, all of Venango County, the eastern portion of Forest County, and all of Clarion, Armstrong, and Butler counties.

The production of this district in 1897 was 6,825,599 barrels, as compared with 7,539,807 barrels in 1896, showing a decrease of 714,208 barrels. The number of wells completed in this district in 1897 was 1,792, as compared with 2,767 in 1896, a falling off of 975 wells. There were no new pools developed during 1897 in this very large district, and the falling off of 35 per cent in the number of new wells indicates that this district, so far as present developments go, has passed its maximum production and is on a steady decline.

Allegheny County district.—This county has been made a separate district. The production in 1897 was 2,958,540 barrels, as compared with 4,380,007 barrels in 1896, a decrease of 1,421,467 barrels. This is the largest proportional decrease of any of the districts. No fresh territory worthy of the name was developed. The new wells drilled were all in developed territory, and in a measure divided the production with the older ones.

Washington County district.—This county is also considered as a district by itself. Its production in 1897 was 2,175,712 barrels, as compared with 1,975,169 barrels in 1896, an increase of 200,543 barrels. No new territory was developed in this county in 1897, and the increase must have come from wells in developed territory.

Beaver County district.—This county is also a district. Its production in 1896 was 550,296 barrels, as compared with 317,926 barrels in 1897, a decrease of 232,370 barrels. Nothing was developed in the way of new territory in this county, the old field having a large number of old wells with a gradually decreasing production.

Greene County district.—The Blackshire pool in this county did not develop an extensive area, and out of ten wells drilled around the original well only two were small producers.

Several large gas wells were developed in southern Greene County during 1897, one of which was found in the southeastern extension of Franklin Township.

Early in March, 1897, a well located on the William Fonner farm, near Dunn station, pierced what is known as the "Fifty-foot" sand, and began to flow at the rate of 300 barrels per day. It was afterwards drilled deeper and its production increased to 1,400 barrels a day, and at the beginning of the year it was producing at the rate of 200 barrels a day. This well was surrounded by several others, only one of which proved to be paying up to the close of the year. All of the wells in this part of Greene County are expensive, as the original Fonner well was 2,639 feet to the pay streak. Some of these wells must have been 2,800 to 2,900 feet deep. Near Graysville a few wells were drilled to the lower sands and found productive, yet there were probably two dry holes to one producing well in this field.

In the northeastern corner of Aleppo Township, Greene County, a well was drilled on the Woods farm in August, 1897, which made over 200 barrels, and was continuing at 90 barrels at the close of the year.

Franklin district.—In the area lying between the Allegheny River and French Creek at Franklin, Venango County, there is a production of natural lubricating oil, known as the Franklin lubricating oil, whose peculiar qualities are known to the operators of all the leading railroads in the United States and Europe. It is purchased principally by the Galena Oil Company, of Franklin, Pennsylvania, and marketed by them. This oil comes from what is known as the first sand, and is found at a depth of about 300 feet on the river bottoms. The sand is about 50 feet thick, and holds this oil invariably associated with salt water. The entire field extends back 4 miles from the river, and is approximately 4 miles long, reaching back to the waters of Sugar Creek. The wells are pumped in clusters of from 50 to 100, many of them only producing a few gallons per day. The gravity of this oil in the old field, which has been producing for years, is 32° Baumé, and in the area outlying the old field it is about 34°. Its fluidity is not in any way affected by zero temperature.

The natural lubricating petroleum found at Volcano and Petroleum, in West Virginia, and that of the Mecca and Belden districts, in Ohio, have similar qualities, and are also highly prized as lubricating oil, although the amount of their production is not one-fifth of that at Franklin, Pennsylvania. The production of this field in 1897 was 48,880 barrels, and for a number of years has been about 50,000 barrels a year.

SOUTHEASTERN OHIO.[1]

Monroe County.—At the beginning of the year the Benwood pool continued to be the most active portion of this part of Ohio. A number of good wells were drilled in the early part of the year, but toward the close of the year all of the rich territory had been determined, a large number of dry holes having been drilled.

Near Cameron, in the northeastern portion of the county, there were a number of wells that gave promise of opening up a new field, but a number of dry holes were drilled and floods of salt water were discovered, discouraging further prospecting.

Many of the old wells in this part of the Sistersville pool continue to keep up close to their regular production, although nothing like an extension of this field has been found.

Washington County.—In the Wilson Run field a number of good producers were found; which have helped to stay the decreasing production, and considerable drilling has been done in the old Macksburg field.

WEST VIRGINIA.

The great increase in the production of crude petroleum in this State, amounting to 30.6 per cent, is remarkable. The production of 1896 was a little over 10,000,000 barrels, and that of 1897 a little over 13,000,000 barrels.

Tyler County.—In this county a very prolific oil field, known as the Elk Fork pool, was opened. Early in March the original Wood well, located on Elk Fork of Point Pleasant Creek, 8 miles northeast of Middlebourne, was completed. The oil comes from what is known as the "Keener" sand, which is immediately above the "Big Injun" sand. By the close of the month the original well had produced 4,170 barrels. This attracted many operators, and wells were put down in quick succession. By the close of April, thirteen large wells had been added to the original well in a comparatively small area.

Shortly after this several small wells and dry holes were developed, and the pool was considered to have its limits defined, but the discovery of a rich streak extending in a southwestern direction gave a new lease of life to the pool. By the first of May 14 wells had been completed in the Elk Fork pool, and the production was 20,626 barrels. Seven more were completed during the month, and the production for May amounted to 43,099 barrels. From this time on the development proceeded very rapidly. At the end of June there were 37 wells which had produced 74,643 barrels; by the end of July 63 wells, with a production of 133,458 barrels; by the end of August 108 wells, with a total production for the month of 223,458 barrels; by the end of September 122 wells, with a production of 266,635 barrels; by the end of October

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[1] That part included in the southwestern district.

154 wells, with a production of 260,038 barrels; by the end of November 172 wells, with a production of 240,758 barrels, and by the close of December 192 wells, which produced 241,891 barrels for that month. These 192 wells, exclusive of dry holes, produced from March 1 to the end of the year, a total of 1,504,290 barrels, and Elk Fork was by far the most productive pool developed in 1897 anywhere in the Appalachian field.

The Conway pool, almost connecting with the Elk Fork pool, contributed several wells of moderate production. Some of these wells showed large volumes of gas in the upper part of the sand, and upon drilling deeper, after the gas had been exhausted, produced oil.

There were in both these pools 237 wells drilled in 1897, and out of this number 35 were gas wells or dry holes.

In the southern portion of this county, in the Hebron pool, a number of good wells were secured in the Cow Run and Big Injun sands.

The Gordon sand development continues southeast from the head of Pine Fork, in Wetzel County, into Tyler County in a wide belt to the Indian Creek branch of Middle Island Creek. This region has developed a very remarkable regularity. A number of wells were drilled in 1897, and while none were gushers, they can be counted on for a production of from 50 to 150 barrels daily for a long period. The wells are deep, however, and a dry hole means a loss of from $6,000 to $7,000. This part of Tyler County has also helped to swell the total of the State of West Virginia.

The Kyle pool, which produced such an excitement in the early part of 1896, owing to the discovery of both oil and gas, is in this county. Now, however, it is reduced to pumping wells of small production, and many of the original producing wells have been abandoned.

The original Sistersville pool, in the western edge of Tyler County, still continues to produce oil from the Big Injun sand in considerable quantity, although over six years old. The main Big Injun development extends along the southeastern dividing line, near Doddridge County. The pools near Wick and Sancho creeks continue to furnish considerable oil. Tyler County is of interest, owing to the number of oil and gas pools, and to the fact that it is located at the southwestern terminal of the bottom of the deep trough extending southwest from Greene County, Pennsylvania, and southeast from Ohio. Here this trough begins to rise toward the southwest. There are also parallel folds to the northwest that have caused the unusual meanderings of Middle Island Creek. One of the prominent uplifts is the Owlhead Peak, and around the three sides of this peak, but several miles away, flows Middle Island Creek.

Wetzel County.—This county has added a large amount to the production of West Virginia in both oil and gas. The region near the headwaters of Ten Mile, Pine Forks, and Buck Run, on the eastern rise of the basin, continue to furnish oil from the Big Injun sand, but lately the Gordon sand has been found to hold oil in paying quantities. The Gordon development was originally opened up by a well on a branch of Buffalo Creek, near where it joins Fishing Creek. To the north of Fishing Creek a few moderately good Gordon wells have thus far been found. To the southwest, on a line crossing near the head of Pine Forks, extending to the Tyler County line and widening out into a broad belt, a number of large wells have been found in the Gordon sand. A gas well on the Cunningham farm, on Pine Forks, gave a temporary flow of gas said to equal, if not to surpass, that of the "Big Moses." A large amount of gas is furnished from this arch, which crosses near the mouth of Middle Run of Fishing Creek and extends northeast toward Old Hundred, on the Baltimore and Ohio Railroad. Several large gas wells have been found near Uniontown.

Marion County.—This is the county in which the first Big Injun well was found south of Mount Morris, in the fall of 1889, near Mannington. This county has a continued line of producing wells in the Big Injun sand, extending from near Joetown on the southwestern border to Fairview, crossing the Baltimore and Ohio Railroad at Mannington. It has not materially changed in any particular during 1897.

The Flat Run Gordon sand pool has been extended northeast until the line of Monongalia County has been crossed 2 miles or more, and a number of good wells have been secured. In this pool there are several producing wells about 3,600 feet deep, the oil sand being about 1,950 feet below ocean level. Three miles west of where the Flat Run development crosses the Baltimore and Ohio Railroad the Campbells Run development crosses the same road. In this pool the largest wells drilled during 1897 are located. One on the Moore farm, Campbells Run, produced 1,800 barrels during the first twenty-four hours, and at the end of the first sixty days had produced 57,000 barrels. At the close of the year, when the well was more than three months old, it was producing about 700 barrels a day. This pool is about 3 miles long as developed, and the wells have remarkable lasting qualities so far.

Monongalia County.—The Flat Run pool has been extended into this county, but so far only one or two good wells have been found. The Campbells Run development is pointing directly for this county, and will in all probability extend into it.

Several deep sand wells were drilled on Dunkard Creek, in this county, near the Pennsylvania line, and a small production secured in the Elizabeth sand.

The original Big Injun belt crosses this county in a northeasterly direction from Fairview to Mount Morris, and in this county were located some of the largest Big Injun wells.

Doddridge County.—Near to the northwestern border of this county and on a line parallel to it for 12 miles, with a few gaps, is the regular Big Injun development. Several good wells have been secured the past year in what was known as developed territory.

Harrison County.—In this county two wells have reached a lower sand in which oil was found in considerable quantity. This pool is in the southwestern portion of the county.

Ritchie County.—This county was the scene of a large amount of drilling in 1897. Heretofore most of the production came from the neighborhood of Cairo, where the salt sand and the Big Injun sand produced the oil, but early in the year a well at Cornwallis began producing a large amount of oil from the lower salt sand, which lies above the Big Injun about 150 feet, the "Big Lime" being found between these sands. Many wells were drilled near this first well. The highest production of the pool amounted to 1,500 barrels a day. After the maximum the decline was rapid until the wells settled down to their regular production.

Two and one-half miles southeast of Cairo there was some new territory opened up, and near the Ritchie mines some producing wells were found in the salt sand. At the Ritchie mines, some 10 miles southwest of Cairo, there is an almost vertical dike of tar or bitumen 4 feet wide and extending 7 miles. To the casual observer it resembles coal, but on the application of sufficient heat it liquefies before it is consumed. Attempts were made to distill it in the manufacture of oil some thirty-five years ago. It is known as grahamite or Ritchie mineral. Some of the wells have produced oil from the salt sand within a few hundred feet of this fissure or dike.

Wood County.—The Ogden pool has continued to furnish a number of good wells from the Berea and Cow Run sands.

The Hendershot pool also furnished a number of good wells from the same sands, and while none of these wells were gushers, they were very fair producers, and there was a very small proportion of dry holes. There were a number of dry holes in the Cow Run or Dunkard sand territory, but these were shallow and therefore not expensive.

Pleasants County.—This county has continued to produce some oil from the Cow Run and Berea sands, in the Eureka, Hebron, and French Creek pools.

Marshall County.—There is still some production in this county from the Cow Run Sand pool northwest of Moundsville.

Lewis County.—There are a few wells producing oil and salt water from the Fifty-foot sand in the northwestern corner of the county.

Roane and Calhoun counties.—These counties have been prospected over to some extent, and considerable gas and some oil shows have been found outside of the old production at Burning Springs. A number of wells have been completed near the southern edge of producing territory, but the field has not been extended south during 1897 beyond limits that have already been defined.

Several wells have also been drilled on the waters of the Big Kanawha and those of the Big Sandy, which have not developed oil in paying quantities.

KENTUCKY.

Eastern Kentucky.—The New Domain Oil and Gas Company and the Corning Oil Company completed the following wells in 1897 in Floyd and Martin counties:

List of wells in eastern Kentucky completed in 1897.

County.	Name of well.	Location.	Result.	Company.
Floyd....	G. T. Kendricks, No, 1.	Upper Cow Creek	Dry	New Domain Oil and Gas Co.
Do....	Eliz Reffitt, No. 1....	Lower Fork Middle Creek.	Small show of oil.	Do.
Do....	T. J. Webb, No. 1 ...	Henry Branch Right Beaver.	Small gasser....	Do.
Do....	Jack Allen, No. 2....	Near mouth Salt Lick.	Dry	Do.
Do....	Jos. Gray, No. 1	Bull Creek............	.....do	Do.
Do....	Allen Transfer, No. 1.	Middle Creek.........	Small show of oil.	Do.
Do....	A. S. Crisp, No. 1.....	Bucks Branch	Dry.............	Do.
Do....	Jos. Hicks, No. 1.....	Head of Brush Creek.	Small show of oil.	Do.
Do....	Marion Rice, No. 1 ..	Prater Creek	Dry.............	Do.
Do....	A. C. Hagans........	Right Beaver Creek ..	.....do	Corning Oil Co.
Do....	....	Wilson Creek.........	Small gasser....	Do.
Martin .	Jackson Cassady	Cold Water Fork	Fair gasser	New Domain Oil and Gas Co.

The oil developed so far is comparatively insignificant in all of eastern Kentucky, although there are a few small wells on Beaver Creek near the mouth of Salt Lick that have never yet had a chance to develop their staying qualities. To test these wells the National Transit Company has completed two 15,000-barrel iron tanks on Right Beaver Creek. This oil is found in the salt sand above the Big Injun. There is a prospect of the gas in and about Warfield, some 45 miles above Catlettsburg, developed about fourteen years ago, being utilized in Huntington, Catlettsburg, Ashland, and Ironton.

Central and southern Kentucky.—There is some production in southern Kentucky, near Glasgow, Barren County, from Calcareous sands which are found at the bottom of the mountain, or Subcarboniferous limestone, and possibly from the Corniferous limestone. This development is from eighteen to twenty years old. There is a little development on the Cumberland River near Burksville, which dates back to 1864 and 1865. Oil was found here in 1829 in a well drilled for salt water. It flowed until 1860, most of the oil escaping into the Cumberland River. There is also some heavy oil produced in Wayne County near the headwaters of Otter Creek. The twelve deep wells drilled in 1896, and noted in the report for that year, have been followed by only two or three wells drilled in Wayne County in 1897. The character of the material penetrated by the drill in nearly all these wells has indicated that it is not of the kind in which reservoirs of oil are usually found. There are also a number of producing wells in Wayne County. Six wells have been drilled during the past five years at Slickford, on Otter Creek, known as the Hovey wells, that have a combined production of about 250 barrels a day of dark oil with a gravity of about 34°. Eleven wells, known as the Williams wells, farther northwest, were drilled several years before. There are also four wells on Beaver Creek; one on Big Sinking Creek, known as the Pennsylvania well; another on Little Sinking Creek, owned by the Chicago Petroleum Company; and two wells on the South Fork of the Cumberland River, near the mouth of Rock Creek. Most of these are producers, and have a combined capacity estimated at from 300 to 500 barrels a day. Owing to the distance of most of these wells from lines of transportation they are not operated to any extent. A few wells in the southeastern portion of Pulaski County have developed the presence of an oil of high gravity, but the quantity thus far found has been small.

There is at this time scarcely any prospecting work going on in this part of Kentucky.

PRODUCTION OF APPALACHIAN OIL FIELD FROM 1889 TO 1897, BY STATES.

The difficulty in completely separating the New York and Pennsylvania production, owing to the Bradford pool continuing without interruption from one State to the other, has made it necessary to combine the totals for these two States.

Production of petroleum in the Appalachian oil field from 1889 to 1897.

[Barrels of 42 gallons.]

Year.	Pennsylvania and New York.	West Virginia.	Southeastern Ohio.	Total.
1889	21,487,435	544,113	318,277	22,349,825
1890	28,458,208	492,578	1,116,521	30,067,307
1891	33,009,236	2,406,218	424,323	35,839,777
1892	28,422,377	3,810,086	1,193,414	33,425,877
1893	20,314,513	8,445,412	2,602,965	31,362,890
1894	19,019,990	8,577,624	3,184,310	30,781,924
1895	19,144,390	8,120,125	3,694,624	30,959,139
1896	20,584,421	10,019,770	3,366,031	33,970,222
1897	19,262,066	13,090,045	2,877,838	35,229,949

From the above table it is shown that the production for the year 1897 falls only 609,828 barrels below the maximum production, that of 1891. There is an increase, however, of 1,259,727 barrels in 1897 over that of 1896, or a little under 4 per cent.

PRODUCTION IN THE APPALACHIAN OIL FIELD, BY MONTHS.

In the following table is given the production of crude petroleum in the Appalachian oil field from 1892 to 1897, by months:

Production of crude petroleum in the Appalachian oil field from 1892 to 1897, by months.

[Barrels.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.
January	3,016,062	2,491,853	2,627,123	2,469,941	2,727,891	2,754,761
February ...	2,923,272	2,350,490	2,330,582	2,083,087	2,528,867	2,663,406
March	2,885,531	2,769,501	2,671,051	2,504,645	2,711,088	2,935,568
April	2,802,221	2,493,590	2,494,772	2,588,727	2,933,487	2,809,148
May	2,741,848	2,673,648	2,654,299	2,586,710	2,888,502	2,902,571
June	2,757,436	2,669,110	2,637,416	2,488,551	2,916,018	2,990,489
July	2,759,309	2,658,141	2,659,718	2,673,621	2,972,001	3,035,334
August......	2,851,348	2,757,351	2,605,494	2,753,417	2,871,118	3,115,375
September ..	2,698,196	2,682,296	2,465,689	2,685,766	2,831,507	3,035,321
October	2,729,444	2,651,591	2,638,689	2,717,958	2,901,781	3,078,061
November...	2,606,646	2,513,281	2,460,880	2,661,700	2,745,756	2,983,616
December...	2,654,564	2,652,038	2,536,211	2,745,016	2,942,206	2,926,299
Total..	33,425,877	31,362,890	30,781,924	30,959,139	33,970,222	35,229,949

From the above table it is observed that in 1897 there was a gradual increase to August, and considering that September is one day shorter than that month, the daily average is the greater. The severe weather and the short days of winter cut down the production somewhat, yet it is remarkable what a slight variation there was during 1897.

AVERAGE DAILY PRODUCTION OF THE APPALACHIAN OIL FIELD FROM 1892 TO 1897, INCLUSIVE, BY MONTHS AND YEARS.

The daily average production, which follows closely the pipe-line runs reported daily in all the oil exchanges, is generally accepted by the producer and refiner as the standard by which comparisons are made. The amounts are obtained by dividing the monthly production by the number of days in each particular month. The average yearly production is secured by dividing the total by 365 or 366, as the case may be.

Average daily product of crude petroleum in the Appalachian oil field each month for the years 1892 to 1897, by months and years.

[Barrels.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.
January	97, 292	80, 382	84, 746	79, 676	87, 996	88, 863
February	100, 802	83, 946	83, 235	74, 396	87, 202	95, 122
March	93, 082	89, 339	86, 163	80, 795	87, 454	94, 695
April	93, 407	83, 120	83, 159	86, 291	97, 783	93, 638
May	88, 447	86, 247	85, 622	83, 443	93, 177	93, 631
June	91, 915	88, 970	87, 914	82, 952	97, 201	99, 683
July	89, 010	85, 746	85, 797	86, 246	95, 871	97, 914
August	91, 979	88, 947	84, 048	88, 820	92, 617	100, 496
September	89, 940	89, 410	82, 190	89, 526	94, 384	101, 177
October	88, 047	85, 535	85, 119	87, 676	93, 606	99, 292
November	86, 888	83, 776	82, 030	88, 723	91, 525	99, 454
December	85, 631	85, 550	81, 813	88, 549	94, 910	94, 397
Average	91, 328	85, 926	84, 334	84, 820	92, 815	96, 520

The variation, as compared to the average for the year, was from 8 per cent less in January to 5 per cent greater in September. The average daily production in 1897 shows an increase of 3,705 barrels over 1896. The above table includes some oil not handled by the pipe lines, owing to its proximity to refineries, to which it is hauled or delivered by private lines.

PIPE-LINE RUNS IN THE APPALACHIAN OIL FIELD IN 1897.

Usually the terms "production" and "pipe-line runs" are considered as synonymous, but production is always slightly in excess of runs. The expression "pipe-line runs" means the amount of oil that the pipe lines have received from the wells, and as the pipe lines do not run all the oil in the tanks at the wells, it would be remarkable if the same amount remained in the tanks at the wells at the close of each year. The true yearly runs would be obtained if there were the same amount on hand at the end of the year that there was at the beginning. If there were more the difference should be subtracted from the total runs to get the total production. As there is some oil delivered to cars and to refineries that is not handled by the pipe lines the total production will be more than the pipe-line runs. The production in the Appalachian oil field in 1897 was 35,229,949 barrels, the runs 34,773,536, making a difference of 456,413 barrels in excess of pipe-line runs.

In the following table will be found the pipe-line runs in the Appalachian oil field in 1897, by lines and by months:

Pipe-line runs in the Appalachian oil field in 1897, by lines and months.

[Barrels.]

Month.	National Transit.	Tide Water.	Southwest.	Franklin.	Eureka.	Elk.	Emery.	Producers and Refiners' Pipe Line Company, Limited.	Buckeye-Macksburg.	Total.
January	814,395	155,979	428,697	1,874	843,187	21,223	26,046	91,448	289,720	2,672,569
February	809,756	156,727	432,189	3,710	841,500	18,860	24,494	90,349	263,896	2,641,481
March	873,243	167,480	489,766	5,830	935,048	21,345	28,539	111,452	284,298	2,917,001
April	811,762	159,534	452,669	4,442	956,138	19,470	25,489	108,779	255,715	2,793,998
May	803,241	154,602	455,213	3,986	997,021	19,702	25,518	130,138	266,687	2,856,108
June	816,893	157,058	478,852	3,881	1,056,300	19,119	27,445	126,271	257,925	2,943,744
July	817,532	157,433	469,169	5,383	1,142,486	19,355	24,294	120,203	242,160	2,998,015
August	810,310	148,745	454,934	3,964	1,257,787	18,559	23,094	117,032	232,208	3,066,633
September	803,827	143,874	424,936	3,857	1,261,028	18,551	23,221	112,280	214,283	3,005,857
October	855,496	142,360	421,649	3,906	1,247,620	17,712	27,362	108,008	202,847	3,026,960
November	804,381	136,240	403,529	4,159	1,263,304	17,027	34,168	100,178	190,028	2,953,014
December	786,784	142,448	417,755	3,888	1,207,522	16,894	28,404	100.322	194,168	2,898,185
Total	9,807,620	1,822,480	5,329,358	48,880	13,008,941	227,817	318,074	1,316,460	2,893,935	34,773,565

SHIPMENTS OF PETROLEUM FROM THE APPALACHIAN FIELD.

The following table gives the total deliveries of petroleum by pipe lines in the Appalachian field from 1890 to 1897, inclusive, by years and months. These figures must not be regarded as showing the actual consumption. They represent what the pipe line companies transported out of their receiving tanks and delivered to customers in the regular way of business, amounting to 33,664,324 barrels in 1897, as compared to 29,340,195 barrels in 1896, a gain of 4,324,129 barrels over 1896 in the number of barrels transported in 1897:

Total shipments of petroleum in the Appalachian oil field from 1890 to 1897, by months.

[Barrels.]

Month.	1890.	1891.	1892.	1893.
January	2,681,646	2,475,783	2,420,825	2,957,358
February	2,185,007	2,170,172	2,443,546	2,584,742
March	2,184,018	2,430,705	2,586,075	2,843,938
April	2,348,385	2,157,605	2,338,421	2,666,199
May	2,488,036	2,073,199	2,278,027	3,033,700
June	2,509,056	2,163,811	2,108,386	3,074,443
July	2,687,061	2,260,996	2,314,405	3,319,658
August	2,645,399	2,498,573	2,626,043	3,248,873
September	2,711,887	2,704,645	2,770,472	3,000,740
October	2,783,121	2,802.254	2,824,508	3,316,914
November	2,717,439	2,604,135	2,916,265	3,096,578
December	2,743,225	2,783,766	2,978,921	3,152,238
Average	2,557,023	2,427,137	2,550,491	3,024,615
Total	30,684,280	29,125,644	30,605,894	36,295,381
Month.	**1894.**	**1895.**	**1896.**	**1897.**
January	3,141,722	3,140,864	2,543,518	2,538,501
February	2,656,026	2,808,801	2,252,417	2,311,488
March	2,912,594	2,608,232	2,438,900	2,773,710
April	2,846,805	2,781,379	2,227,514	2,454,018
May	2,819,413	2,845,334	2,418.590	2,546,696
June	2,914,400	2,816,698	2,249,062	2,556,161
July	2,927,036	2,634,880	2,540,332	2,707,317
August	3,256,397	2,424,843	2,404,298	3,100,209
September	2,966,864	2,332,271	2,542,963	2,956,036
October	3,271,371	2,573,915	2,606,494	3,638,301
November	3,208,560	2,655,325	2,502,035	3,320,084
December	3,286,087	2,410,084	2,614,072	2,761,803
Average	3,017,273	2,669,386	2,445,016	2,805,360
Total	36,207,275	32,032,626	29,340,195	33,664,324

STOCKS OF PETROLEUM IN THE APPALACHIAN OIL FIELD.

In the following table will be found a statement of the stocks of petroleum in the tanks of the pipe-line companies in the Appalachian oil field at the close of each month from 1890 to 1897:

Total stocks of petroleum in the Appalachian oil field at the close of each month from 1890 to 1897.

[Barrels of 42 gallons.]

Month.	1890.	1891.	1892.	1893.
January	11, 356, 634	11, 068, 179	16, 973, 225	17, 305, 206
February	11, 282, 453	11, 340, 147	17, 416, 399	17, 042, 245
March	11, 472, 854	11, 419, 782	17, 587, 512	16, 834, 533
April	11, 503, 776	11, 793, 604	18, 028, 753	16, 641, 773
May	11, 445, 975	12, 138, 347	18, 464, 378	16, 285, 855
June	11, 318, 438	12, 455, 630	19, 056, 902	15, 845, 548
July	11, 170, 539	12, 640, 790	19, 446, 441	15, 182, 551
August	11, 057, 828	12, 791, 156	19, 563, 635	14, 730, 600
September	10, 942, 934	13, 039, 230	19, 394, 242	14, 261, 432
October	10, 923, 831	13, 936, 108	19, 039, 149	13, 559, 543
November	10, 783, 567	15, 413, 864	18, 529, 914	12, 904, 344
December	10, 691, 729	16, 457, 089	18, 037, 385	12, 316, 611
Average	11, 162, 547	12, 874, 494	18, 461, 495	15, 242, 520

Month.	1894.	1895.	1896.	1897.
January	11, 755, 219	5, 859, 348	5, 499, 477	9, 904, 200
February	11, 384, 776	5, 087, 498	5, 741, 797	10, 308, 262
March	11, 295, 959	4, 942, 643	6, 005, 732	10, 426, 110
April	10, 751, 983	4, 730, 819	6, 697, 481	10, 772, 213
May	10, 639, 454	4, 506, 874	7, 153, 922	11, 088, 495
June	10, 381, 209	4, 275, 506	7, 791, 359	11, 485, 001
July	9, 869, 915	4, 306, 287	8, 182, 582	11, 830, 322
August	9, 210, 959	4, 592, 906	8, 672, 385	11, 794, 707
September	8, 730, 456	4, 908, 593	8, 924, 639	11, 872, 575
October	8, 038, 376	5, 013, 941	9, 178, 509	11, 246, 836
November	7, 283, 988	4, 988, 092	9, 409, 098	10, 870, 883
December	6, 499, 880	5, 344, 784	9, 745, 722	11, 010, 044
Average	9, 653, 515	4, 879, 775	7, 750, 225	11, 050, 801

The foregoing table shows a decided increase in the amount of crude petroleum stored in the tanks of the several pipe-line companies at the close of the year, a gain of 1,264,322 barrels in 1897 above the stocks at the end of 1896, and it is upon this oil in stock as security that pipe-line certificates are issued. This they must protect by the purchase of fresh oil, if necessary to make good any loss by evaporation, bursting of pipes, losses by fire, or settlings in the bottoms of tanks of paraffin, sand, and water, known as B. S., which is unsalable for refining purposes.

The shipments added to or subtracted from stocks, as the case may be, are always less than the runs, and oil is purchased by the pipe-line company to make good these losses, but the purchased oil does not appear in the statement of runs. The table of stocks does not include all the oil held, but only that held by the pipe-line companies. A large percentage is held temporarily at the wells in individual tanks.

PRICES OF CRUDE PETROLEUM IN THE APPALACHIAN OIL FIELD.

The prices of crude petroleum in the Appalachian oil field, as arranged in the following table, show the monthly and yearly average price of pipe-line certificates, or the price of crude petroleum at the primary markets, from 1860 to 1897. In the early history of the industry covered by the table, before the introduction of pipe lines, the prices quoted usually meant the price at the wells or at some point not far distant. In late years the price given is that of pipe-line certificates, which are issued to holders of a thousand barrels of oil in any of the districts. Or a producer or owner may "bunch" his production in the different districts to secure the issuing of a 1,000-barrel certificate, as soon as it has been run into the tanks of the pipe-line company. These certificates are made payable to bearer and are therefore transferable; they are subject to a transportation charge in the district of 20 cents per barrel, and a charge for storage at the rate of 25 cents per 1,000 barrels, when the price is less than $1, 30 cents when over $1 and less than $1.50, and 40 cents for all over $1.50 per barrel. It is to be returned for exchange to the pipe-line company within six months after its issue, or subject to a charge of one-twentieth of 1 per cent daily thereafter until exchanged. To cover losses by fire or lightning, it is subject to an assessment pro rata on all oil in the custody of the pipe line. None of these charges are included in the prices of petroleum as quoted, and therefore the prices given are the prices at or near the wells.

The average price covers the ordinary grades of oil. They do not include special oils, such as that from the Franklin lubricating district or that of Petroleum and Volcano of West Virginia nor the Mecca-Belden district of Ohio, but only such oil as Pennsylvania oil and such as is used chiefly for the production of illuminants. It is also true that in some of the districts oil is worth more than ordinary Pennsylvania oil, and in some districts it is worth less. This is owing to the fact that some districts produce oil that furnishes a larger percentage of illuminating oil and a larger percentage of by-products. Oil that has remained in tanks at the wells for a long period loses a percentage of its illuminating properties and is worth less than what is known as fresh oil or petroleum recently produced at the wells.

These averages, it should be understood, are not the true averages—that is, averages that consider the price and the quantity sold at that price—but they are the averages of the prices obtained for certificate or for oil at the primary markets from day to day. It is probable that the true average prices would be slightly under the averages obtained by averaging the prices. The figures given in the following tables are, under these conditions, the only ones that can be ascertained, and do not vary much from the true average:

Monthly and yearly average prices of pipe-line certificates of crude petroleum at wells from 1860 to 1897.

[Per barrel.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1860....	$19.25	$18.00	$12.62½	$11.00	$10.00	$9.50	$8.62½	$7.50	$6.62½	$5.50	$3.75	$2.75	$9.59
1861....	1.00	1.00	1.00	.62½	.50	.50	.50	.25	.20	.10	.10	.10	.49
1862....	.10	.15	.22½	.50	.85	1.00	1.25	1.25	1.25	1.75	2.00	2.25	1.05
1863....	2.25	2.50	2.62½	2.87½	2.87½	3.00	3.25	3.37½	3.50	3.75	3.85	3.95	3.15
1864....	4.00	4.37½	5.50	6.56	6.87½	9.50	12.12½	10.12½	8.87½	7.75	10.00	11.00	8.06
1865....	8.25	7.50	6.00	6.00	7.37½	5.62½	5.12½	4.62½	6.75	8.12½	7.25	6.50	6.59
1866....	4.50	4.40	3.75	3.95	4.50	3.87½	3.00	3.75	4.50	3.39	3.10	2.12½	3.74
1867....	1.87½	1.85	1.75	2.07½	2.35	1.90	2.62½	3.15	3.40	3.55	2.50	1.87½	2.41
1868....	1.95	2.00	2.55	2.82⅛	3.75	4.50	5.12½	4.57½	4.00	4.12½	3.75	4.35	3.62½
1869....	5.75	6.95	6.00	5.70	5.35	4.95	5.37½	5.57½	5.50	5.50	5.80	5.12½	5.63¾
1870....	4.52½	4.52½	4.45	4.22½	4.40	4.17½	3.77½	3.15	3.25	3.27½	3.22½	3.40	3.86
1871....	3.82½	4.38	4.25	4.01	4.60	3.85½	4.79	4.66	4.65	4.82½	4.25	4.00	4.34
1872....	4.02½	3.80	3.72½	3.52½	3.80	3.85	3.80	3.58½	3.25	3.15	3.83½	3.32½	3.64
1873....	2.60	2.20	2.12½	2.30	2.47½	2.22½	2.00	1.42½	1.15	1.20	1.25	1.00	1.83
1874....	1.20	1.40	1.60	1.90	1.62½	1.32½	1.02½	.95	.95	.85	.55	.61½	1.17
1875....	1.03	1.52½	1.75	1.36½	1.40	1.26½	1.09	1.13	1.33	1.32½	1.44	1.55	1.35
1876....	1.80	2.60	2.01	2.02½	1.90½	2.01¾	2.24½	2.71⅜	3.81	3.37½	3.11	3.73	2.56¼
1877....	3.53¼	2.70	2.67½	2.58	2.24	1.94⅝	2.07½	2.51	2.38	2.56¾	1.91	1.80	2.42
1878....	1.43	1.65¼	1.59	1.37½	1.35¼	1.14	.98¾	1.01	.86⅝	.82½	.89⅜	1.16	1.19

Monthly and yearly average prices of pipe-line certificates of crude petroleum at wells from 1860 to 1897—Continued.

[Per barrel.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1879....	$1.03	$0.98	$0.86¼	$0.78½	$0.76	$0.68⅝	$0.69⅞	$0.67⅛	$0.69⅝	$0.88⅛	$1.05⅜	$1.18⅛	$0.85⅞
1880....	1.10¼	1.03⅛	.88¾	.78	.80	1.00	1.06¼	.91	.96	.96⅞	.91⅞	.91⅝	.94¼
1881....	.95½	.90⅝	.83⅜	.86¼	.81⅞	.81¼	.76⅞	.78⅛	.97⅛	.91¼	.85¼	.84⅝	.85⅞
1882....	.83⅛	.84½	.81⅝	.78⅝	.71½	.54⅝	.57⅝	.58⅜	.72⅛	.93¾	1.14	.96	.78⅛
1883....	.93¾	1.01	.97⅝	.94⅝	1.00⅛	1.16⅝	1.05⅞	1.08	1.12½	1.11⅛	1.14½	1.14¾	1.05¾
1884....	1.11	1.04⅝	.98⅛	.94	.85⅝	.68⅝	.63½	.81⅞	.78	.71⅛	.72½	.74⅝	.83½
1885....	.70⅞	.72⅝	.80⅝	.78½	.79	.82	.92½	1.00¼	1.00¾	1.05⅛	1.04⅝	.89⅝	.87⅞
1886....	.88⅜	.79⅞	.77¼	.74⅛	.70	.66½	.66	.62⅛	.63⅝	.65⅛	.71⅜	.70⅝	.71¼
1887....	.70	.64⅝	.63⅝	.64⅞	.64⅛	.62⅝	.59¼	.60⅛	.67	.70⅞	.73⅞	.80¾	.66¾
1888....	.91¼	.91⅝	.98⅝	.82⅝	.86¾	.75⅞	.80⅝	.90⅛	.93⅝	.90⅝	.85⅝	.89¼	.87⅝
1889....	.86⅝	.89¼	.90⅞	.88	.83⅛	.83⅞	.95⅛	.99½	.99⅛	1.01⅝	1.08½	1.04⅛	.94⅛
1890....	1.05¾	1.05⅛	.90	.82⅝	.88⅞	.89¾	.89⅛	.89¼	.81⅞	.80⅛	.72⅝	.67¼	.86¾
1891....	.74¼	.78⅝	.74¼	.71½	.69¾	.68⅛	.66½	.64	.58½	.60½	.58¾	.59⅝	.67
1892....	.62⅝	.60¼	.57⅛	.57⅞	.57⅝	.54⅛	.52½	.55	.54⅝	.51⅝	.52	.53¼	.55⅝
1893....	.53½	.57⅝	.65¼	.68¾	.58¾	.60¼	.57⅝	.58⅞	.64⅛	.70¾	.73⅞	.78¼	.64
1894....	.79¾	.80⅝	.82	.84¼	.86	.89⅝	.83⅛	.81	.83	.83	.83	.91½	.83⅞
1895....	.99	1.04⅝	1.09¾	1.79	1.74¼	1.53⅝	1.46⅝	1.26⅙	1.22⅝	1.24¼	1.48⅝	1.42	1.35⅞
1896....	1.42⅝	1.36⅝	1.28⅛	1.22½	1.15⅝	1.14¾	1.08¼	1.05	1.12	1.15	1.16	.98	1.17⅞
1897....	.88	.90⅛	.92⅙	.85⅞	.86¾	.86¼	.76¾	.71	.69¾	.67⅝	.65	.65	.78⅝

The above table shows an increase of $4\frac{1}{6}$ cents from January to March; a decrease of $15\frac{5}{12}$ cents from March to July, inclusive; a decrease of $5\frac{3}{4}$ cents between July and August, and a decrease of 6 cents between August and December. The quotation for the latter month and November was 65 cents.

For a number of years the prices of certificate oil, that term meaning the oil taken as standard and merchantable by the pipe lines, ruled the market or selling price of crude petroleum. These certificates were bought and sold on the floor of the oil exchanges. In past years there was a large amount of oil held as stocks, and as these were depleted it was necessary for the pipe-line companies to recall a large number of these certificates. As the stocks were reduced, it came to pass that a comparatively small amount of oil would control the entire trade. On January 23, 1895, the following notice was posted at the various offices of what was known as the Seep Purchasing Agency, Mr. Joseph Seep being the purchaser for the refineries of the Standard Oil Company:

"From this date the prices quoted are not those of certificate oil, but the prices paid by the Seep Purchasing Agency."

There was at times considerable difference in the prices paid for certificates and that paid by the Seep agency, as shown by the quotations at the Oil City Exchange.

To enable anyone wishing to dispose of 1,000 barrels of oil in the tanks of the pipe lines, at the price paid by the oil exchange, the Seep agency will negotiate the sale free of charge for the party having the oil in the line and will pay the average price upon which sales were made in the exchange on that day.

In the following table is given the range of prices paid producers in the Pennsylvania region in 1897. Prices are given for those dates in which changes were made. The great volume of trade is controlled by the prices under Pennsylvania, which includes all the oil sold in New York, nearly all sold in Pennsylvania, nearly all sold in West Virginia, and a very large proportion of that sold in Ohio:

Range of prices paid for petroleum in the Pennsylvania oil regions by the Seep Purchasing Agency in 1897.

Date.	Pennsylvania.	Tiona.	Corning.	Newcastle.	Barnesville.
January 1	$0.90	$1.00	$0.80	$0.65	$0.80
January 18	.88	.98	.78	.63	.78
January 23	.85	.95	.75	.60	.75
February 1	.87	.97	.77	.62	.77
February 2	.90	1.00	.80	.65	.80
February 15	.91	1.01	.81	.66	.81
March 22	.92	1.02	.82	.67	.82
March 23	.93	1.03	.83	.68	.83
March 24	.94	1.04	.84	.69	.84
March 26	.95	1.05	.85	.70	.85
March 30	.96	1.06	.86	.71	.86
April 3	.93	1.03	.83	.68	.83
April 5 (10 a.m.)	.91	1.01	.81	.66	.81
April 5 (12 a.m.)	.88	.98	.78	.63	.78
April 9	.85	.95	.75	.60	.75
April 15	.84	.94	.74	.59	.74
April 28	.83	.93	.73	.58	.73
April 30	.81	.91	.71	.56	.71
May 3	.83	.93	.71	.58	.73
May 5	.86	.96	.71	.61	.76
May 18	.89	.99	.72	.64	.79
May 28	.87	.97	.70	.62	.77
June 24	.85	.95	.68	.60	.75
June 28	.83	.93	.66	.58	.73
June 29	.82	.92	.65	.57	.72
July 2	.80	.90	.63	.55	.70
July 13	.79	.89	.62	.54	.69
July 14	.77	.87	.60	.52	.67
July 19	.75	.85	.58	.50	.65
July 26	.73	.83	.56	.48	.63
August 2	.71	.81	.54	.46	.61
September 9	.69	.79	.52	.44	.59
September 23	.70	.80	.53	.45	.60
October 14	.68	.78	.51	.43	.58
October 15	.67	.77	.50	.42	.57
October 18	.65	.75	.48	.40	.55

WELL RECORDS IN THE APPALACHIAN OIL FIELD.

The following table shows the total number of wells completed each month in the several districts for 1897:

Total number of wells completed in the Appalachian oil field in 1897, by months and districts.

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	84	34	50	93	88	195	55	599
February	54	26	25	57	83	163	30	438
March	70	28	30	57	60	123	46	414
April	58	37	37	72	72	152	58	486
May	75	40	33	107	65	165	63	548
June	65	40	42	122	69	215	51	604
July	76	43	48	123	75	238	35	638
August	61	25	51	99	68	253	44	601
September	48	32	32	69	66	208	34	489
October	54	12	44	68	51	188	29	446
November	30	21	47	59	58	189	22	426
December	21	12	42	64	47	166	31	383
Total	696	350	481	990	802	2,255	498	6,072

The above table does not include the wells drilled in the Franklin lubricating oil district of Pennsylvania, nor the wells in the Volcano and Burning Springs districts of West Virginia, which produce natural lubricating petroleum.

The following table of wells completed in each district during 1897 shows that there was a decrease in the number of wells drilled in all the districts excepting the Allegany district, New York, in which there were 19 more wells drilled in 1897 than in 1896. The activity in this district is noted elsewhere. It also shows that there was a decrease of 1,752 in the number of wells completed in 1897 as compared with 1896, and yet, as noted elsewhere, there was an increase in the production of the field of 1,259,727 barrels of crude petroleum.

Total number of wells completed in the Appalachian oil field in 1896 and 1897.

District.	Wells completed.	
	1896.	1897.
Bradford	769	696
Allegany	331	350
Middle field	594	481
Venango and Clarion	1,614	990
Butler and Armstrong	1,153	802
Southwest	2,744	2,255
Macksburg	619	498
Total	7,824	6,072

The following table gives the number of wells drilled in the Appalachian oil field from 1891 to 1897, inclusive, by months. It will be noticed that the greatest number of wells are usually completed in June, July, August, and September, in which months there is generally the largest production.

Number of wells completed in the Appalachian oil field each month from 1891 to 1897, by months and years.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	310	182	135	189	296	580	599
February	243	180	99	176	212	555	438
March	275	149	143	217	355	542	414
April	288	174	146	278	462	614	486
May	314	174	196	324	658	729	548
June	304	162	228	370	810	793	604
July	334	179	219	342	822	739	638
August	333	143	163	359	814	640	601
September	281	146	179	381	775	644	489
October	246	160	154	394	727	624	446
November	255	174	144	390	638	682	426
December	205	145	174	343	567	682	383
Total	3,388	1,968	1,980	3,763	7,136	7,824	6,072

In the following table is given the initial daily production of new wells in the Appalachian field in 1897, by districts and months. By initial daily production is meant the production of the well when first drilled into the sand, so as to fully open up the pay streak, and this is nearly in all cases the maximum production. These figures do not include any of the production in the lubricating oil districts of Pennsylvania or West Virginia.

Initial daily production of new wells in the Appalachian oil field in 1897.

[Barrels of 42 gallons.]

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	584	181	279	294	1,000	6,452	499	9,289
February	828	95	299	166	1,042	5,760	302	8,492
March	698	108	99	186	622	3,902	433	6,048
April	781	135	143	321	601	5,736	361	8,078
May	692	191	544	440	416	6,814	374	9,471
June	964	154	531	407	831	9,934	287	13,108
July	609	161	1,050	334	591	10,931	158	13,834
August	547	73	1,089	339	457	14,013	465	16,983
September	344	82	1,651	279	366	10,388	240	13,350
October	525	37	3,384	220	462	8,231	170	13,029
November	290	78	1,692	145	321	8,784	192	11,502
December	175	37	934	180	231	8,150	182	9,889
Average	586	111	975	276	578	8,258	305	11,089

For comparison we give below a statement showing the initial daily production of all of the producing wells drilled in the Appalachian field in 1896 and 1897, showing an increase in the whole field of 2,382 barrels, or 14.3 per cent, in initial daily production in 1897 over that of 1896. During the same period the number of wells completed decreased 22½ per cent.

Initial daily production of new wells in the Appalachian oil field in 1896 and 1897.

[Barrels.]

District.	1896.	1897.
Bradford	9,462	7,037
Allegany	1,742	1,332
Middle field	5,968	11,695
Venango and Clarion	5,652	3,311
Butler and Armstrong	13,725	6,940
Southwest	74,081	99,095
Macksburg	5,768	3,663
Total	116,398	133,073
Average	16,628	19,010

Average daily production of new wells in the Appalachian oil field in 1896 and 1897, by districts.

[Barrels.]

District.	1896.	1897.
Bradford	13.7	12.09
Allegany	6.1	4.45
Middle field	12.2	32.58
Venango and Clarion	4.2	4.00
Butler and Armstrong	17	13.69
Southwest	39.4	61.36
Macksburg	13.8	12.13

The above table is remarkable as showing a very large increase in the daily production of the wells in the middle district and those of the southwestern district in 1897 over that of 1896. In all the other districts the changes were slight. This increase is due to the large wells found in the Watsonville pool, middle district, in McKean County, during 1897, and to the lasting qualities of the Gordon sand wells in West Virginia.

The total daily initial production of new wells completed in the Appalachian oil field, beginning with 1891 and ending with 1897, is as follows:

This table shows a gradual increase in initial production for the last five years. Only the year 1891 surpasses 1897. It was in the former year that the McDonald field was opened up.

Total daily initial production of new wells in the Appalachian oil field from 1891 to 1897, by months.

[Barrels.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	13,364	12,249	5,910	8,667	5,938	7,383	9,289
February	6,618	9,992	6,982	5,914	3,662	7,829	8,492
March	7,751	8,661	7,650	6,100	6,150	8,842	6,048
April	7,710	6,751	6,962	7,584	6,388	11,253	8,078
May	7,875	7,793	8,176	7,430	7,859	11,350	9,471
June	5,263	9,585	10,815	11,443	9,909	11,825	13,108
July	6,543	10,669	7,662	9,009	8,786	10,476	13,834
August	13,536	7,861	8,733	7,691	12,204	7,471	16,983
September	18,118	6,347	6,640	6,912	14,728	8,216	13,350
October	46,748	8,833	4,510	7,838	9,916	9,263	13,029
November	33,660	6,932	6,495	7,507	10,374	10,294	11,502
December	15,538	7,580	7,840	5,949	7,089	12,196	9,889
Average	15,227	8,604	7,365	7,670	8,584	9,700	11,089

In the following table the total number of dry holes in the Appalachian field is enumerated for the year 1897 by districts and months. By comparing the number of dry holes to the producing wells, it is found that 26 per cent of all the wells drilled in 1897 were dry holes, as compared with 24.3 per cent in 1896.

Total number of dry holes drilled in the Appalachian oil field in 1897.

Month.	Bradford.	Allegany.	Middlefield.	Venango and Clarion	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	17	3	15	14	27	58	20	154
February	12	4	5	6	29	43	10	109
March	18	5	11	4	23	44	11	116
April	8	9	16	10	26	39	20	128
May	11	2	7	18	24	43	26	131
June	5	6	7	25	24	49	25	141
July	15	4	8	29	28	64	14	162
August	10	4	14	21	22	65	22	158
September	4	7	10	10	33	62	14	140
October	6	3	10	10	14	53	9	105
November	6	2	8	8	28	58	12	122
December	2	2	11	7	17	62	13	114
Total	114	51	122	162	295	640	196	1,580

The number of dry holes in the Appalachian field for 1896 and 1897 in the different districts are noted in the following tables:

Number of dry holes drilled in the Appalachian oil field in 1896 and 1897.

District.	1896.	1897.
Bradford	78	114
Allegany	46	51
Middle field	104	122
Venango and Clarion	261	162
Butler and Armstrong	347	295
Southwest	865	640
Macksburg	200	196
Total	1,901	1,580

In 1897 there were 6,072 wells drilled, of which 1,580 were dry holes, as compared with 7,824 wells, of which 1,901 were dry holes, in 1896. The number of paying wells to one dry hole in 1897 was 2.9; or, in other words, the dry holes represent 35 per cent of the paying wells. In 1896 the corresponding figures were 3.1 and 34 per cent, and in 1895 3.5 and 29 per cent. There were, therefore, a few more dry holes found in 1897 in proportion to the paying wells than in 1896, and an equal proportion to 1895, showing a remarkable parallel for the three years.

In the following table will be found the statement of the number of dry holes drilled in each month from 1891 to 1897, inclusive:

Dry holes drilled in the Appalachian oil field from 1891 to 1897.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	46	37	39	36	76	145	154
February	61	36	24	41	55	147	109
March	52	38	36	54	87	142	116
April	59	40	28	68	110	155	128
May	48	48	41	67	119	175	131
June	72	33	48	84	170	190	141
July	67	43	40	67	181	188	162
August	66	31	40	80	185	151	158
September	41	40	43	102	169	148	140
October	50	37	35	91	176	133	105
November	59	40	28	100	139	160	122
December	43	39	41	85	121	167	114
Total	664	462	443	875	1,588	1,901	1,580

The following table presents a statement of the number of rigs or derricks in course of construction in the Appalachian field at the close of each month in each district in 1897, the average of each month being 297, as compared with an average of 414 per month in 1896:

Rigs building in the Appalachian oil field in 1897.

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	56	22	23	32	46	116	25	320
February	62	22	16	35	45	119	23	322
March	69	28	18	41	39	113	24	332
April	58	45	19	54	43	118	25	362
May	54	30	27	50	34	106	21	322
June	53	20	22	40	45	116	16	312
July	51	14	21	36	38	109	18	287
August	29	21	21	33	41	112	15	272
September	30	14	27	27	31	104	11	244
October	28	18	32	37	44	123	19	301
November	24	13	30	28	44	115	19	273
December	22	11	27	22	33	91	10	216
Average	45	22	23	36	40	112	19	297

In the following table will be found a statement of the number of rigs or derricks building in the Appalachian oil field, by months, from 1891 to 1897, inclusive:

Rigs building in the Appalachian oil field from 1891 to 1897.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	233	110	108	166	270	441	320
February	195	132	107	180	353	450	322
March	218	111	132	187	380	449	332
April	186	100	159	233	457	458	362
May	208	108	144	237	599	439	322
June	234	89	135	238	564	436	312
July	182	96	116	245	576	379	287
August	188	74	114	292	490	360	272
September	131	98	91	254	486	378	244
October	156	108	110	269	464	389	301
November	142	130	143	248	472	419	273
December	112	122	193	248	476	365	216
Average	182	107	129	233	466	414	297

The foregoing table shows a large decrease in new work. The decrease in the average number of rigs building in 1897 as compared to 1896 is 117, as compared to a decrease of 52 on comparing 1896 and 1895, but it has been shown that decrease in wells and rigs does not always mean decrease in production.

In the following table will be found a statement of the number of wells drilling throughout the field in 1897, by districts. There were 130 fewer wells drilling in December of 1897 than there were drilling in January, 1897:

Wells in process of drilling in the Appalachian oil field in 1897.

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	39	21	34	44	100	257	19	514
February	38	24	30	37	71	206	27	433
March	40	34	22	34	74	227	31	462
April	50	35	22	57	62	229	22	477
May	50	35	24	62	61	268	21	521
June	42	40	32	71	75	285	26	571
July	43	29	30	56	77	289	22	546
August	38	21	22	35	67	255	25	463
September	35	17	31	47	63	253	18	464
October	23	23	29	36	56	233	15	415
November	19	16	24	45	45	231	21	401
December	24	14	28	27	43	233	15	384
Average	37	26	27	46	66	247	22	471

The following table gives the number of wells drilling, by months, from 1891 to 1897, inclusive, for comparison, over the entire Appalachian field:

Number of wells drilling in the Appalachian oil field from 1891 to 1897 and the average by months.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	407	264	188	269	418	701	514
February	410	273	214	282	440	621	433
March	401	251	206	330	467	667	462
April	387	230	269	345	635	757	477
May	380	233	291	410	824	727	521
June	407	258	305	430	941	682	571
July	420	204	266	498	902	640	546
August	406	244	248	484	866	625	463
September	397	236	233	489	819	556	464
October	386	246	219	469	794	590	415
November	351	228	277	451	760	627	401
December	286	238	233	456	716	595	384
Average	386	242	246	409	715	649	471

The following table shows the wells completed, the initial production, the dry holes, the wells drilling, and the rigs building in the Appalachian oil field.

This gives the average initial production in 1897, over the entire field, 21.9 barrels a day, as compared with 15.7 barrels per day for 1896:

Well record in the Appalachian oil field in 1897.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	599	9,289	154	514	320
February	438	8,492	109	433	322
March	414	6,048	116	462	332
April	486	8,078	128	477	362
May	548	9,471	131	521	322
June	604	13,108	141	571	312
July	638	13,834	162	546	287
August	601	16,983	158	463	272
September	489	13,350	140	464	244
October	446	13,029	105	415	301
November	426	11,502	122	401	273
December	383	9,889	114	384	216
Total	6,072	*a* 11,089	1,580	*a* 471	*a* 297

a Average.

Tables found under the head of Ohio give detailed information as to wells drilled and initial daily production in that portion of the Appalachian oil field known as the Corning, Macksburg, Steubenville, and Marietta districts, and as to miscellaneous wells in southeastern or southern Ohio, grouped in the previous tables under the head of Macksburg.

The Sistersville district and the districts contiguous are included under the general head of southwest district.

PENNSYLVANIA AND NEW YORK OIL FIELD.

PRODUCTION.

For many years the production of these States covered almost the entire production in the United States, and there was no attempt to separate the output.

It is interesting to give separate statistics for New York, Pennsylvania, West Virginia, and Ohio, so far as they can be given separately, for these States cover nearly the entire production in the Appalachian oil field. This has been done for West Virginia and Ohio. The Bradford field extends continuously from Pennsylvania to New York.

It has been found difficult to separate stocks, shipments, etc., of the four States named above.

In the following table will be found a statement of the production of crude petroleum in New York and Pennsylvania in 1897, by districts and months:

Production of crude petroleum in Pennsylvania and New York in 1897, by districts and months.

[Barrels of 42 gallons.]

District.	January.	February.	March.	April.	May.
Allegany County, N. Y.	59, 655	62, 036	67, 059	66, 355	67, 004
Bradford	319, 647	320, 992	355, 230	335, 422	333, 778
Clarendon and Warren	27, 845	28, 355	34, 147	28, 718	32, 051
Middle district	92, 551	80, 934	85, 977	77, 822	84, 559
Tiona	22, 282	24, 243	25, 667	25, 121	25, 070
Lower district	586, 811	586, 761	640, 392	585, 514	598, 182
Washington County ..	134, 892	143, 827	206, 637	189, 568	190, 105
Allegheny County	294, 816	265, 447	262, 893	257, 969	240, 814
Beaver County	43, 748	32, 961	27, 574	23, 191	24, 118
Greene County	7, 384	7, 032	18, 886	17, 306	19, 681
Total............	1, 589, 631	1, 552, 588	1, 724, 462	1, 606, 986	1, 615, 362
Franklin district	1, 874	3, 710	5, 830	4, 442	3, 986
Smiths Ferry district..	195	190	210	205	200
Grand total.....	1, 591, 700	1, 556, 488	1, 730, 502	1, 611, 633	1, 619, 548

District.	June.	July.	August.	September.
Allegany County, N. Y..	67, 365	67, 433	66, 828	63, 170
Bradford	339, 753	334, 165	322, 260	311, 631
Clarendon and Warren .	31, 923	33, 952	30, 110	32, 689
Middle district	85, 559	102, 801	107, 071	130, 572
Tiona	25, 111	23, 785	24, 540	24, 313
Lower district	584, 780	580, 958	555, 672	533, 738
Washington County	199, 774	195, 021	194, 836	181, 933
Allegheny County	260, 709	242, 956	243, 119	234, 043
Beaver County	26, 248	24, 927	30, 148	24, 772
Greene County	42, 983	35, 792	26, 211	22, 565
Total	1, 664, 205	1, 641, 790	1, 600, 795	1, 559, 426
Franklin district	3, 881	5, 383	3, 964	3, 857
Smiths Ferry district...	200	190	195	200
Grand total	1, 668, 286	1, 647, 363	1, 604, 954	1, 563, 483

Production of crude petroleum in Pennsylvania and New York in 1897, by districts and months—Continued.

[Barrels of 42 gallons.]

District.	October.	November.	December.	Total.
Allegany County, N. Y. .	63, 479	56, 528	64, 694	771, 606
Bradford	314, 212	308, 439	308, 701	3, 904, 230
Clarendon and Warren .	27, 440	35, 920	34, 925	378, 075
Middle district	175, 341	168, 874	137, 387	1, 329, 448
Tiona	24, 660	23, 628	23, 165	291, 585
Lower district	547, 382	512, 478	512, 931	6, 825, 599
Washington County	187, 802	175, 487	175, 830	2, 175, 712
Allegheny County......	224, 351	210, 463	220, 960	2, 958, 540
Beaver County	19, 979	20, 084	20, 176	317, 926
Greene County	16, 600	21, 857	21, 768	258, 065
Total	1, 601, 246	1, 533, 758	1, 520, 537	19, 210, 786
Franklin district	3, 906	4, 159	3, 888	48, 880
Smiths Ferry district...	210	200	205	*a* 2, 400
Grand total	1, 605, 362	1, 538, 117	1, 524, 630	19, 262, 066

a This production only represents dump oil, the pipe-line runs of this district being included in runs of Beaver County.

The production in the Allegany district does not include all of the production in the State of New York. About 15 to 18 per cent of the production in the Bradford district comes from New York, the remainder being from Pennsylvania. The sum total of these two States shows a decrease of 1,322,355 barrels in 1897, as compared with 1896, which year had an increase of 1,440,031 barrels over 1895, so that 1897 is only 117,676 barrels greater than 1895, and 242,076 barrels greater than 1894. The total production for 1894, 1895, and 1897 is nearly equal. In 1897 it was 13,747,170 barrels less than the maximum production of 1891. The increase or decrease of the districts has been already discussed under Appalachian production.

In the following table will be found the total production of crude petroleum in the Pennsylvania and New York oil fields for the twenty-seven years beginning in 1871 and ending with 1897:

Total product of crude petroleum in the Pennsylvania and New York oil fields from 1871 to 1897, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1871......	418,407	372,568	400,334	385,980	408,797	410,340	456,475	462,582	461,940	485,243	464,610	477,958	5,205,234
1872......	583,575	462.985	461,590	462,090	537,106	491,130	517,762	549,909	500,430	442,432	638,610	645,575	6,293,194
1873......	632,617	608,300	665,291	641,520	776,364	793,470	867,473	936,138	954,270	942,493	991.470	1,084,380	9,893 786
1874......	1,167,243	835,492	883,438	778,740	895,745	621,750	1,033,447	931,519	840,630	919,739	861.060	858,142	10,926,945
1875......	852,159	719,824	789,589	675,060	696,508	696,210	788,361	718,766	698,940	731,073	700,200	720,874	8,787,514
1876......	712,225	668,885	718,177	701,490	735,351	723,600	763,623	782,223	780,600	809,162	786,480	787,090	8.968,906
1877......	842,890	783,216	901,697	972,810	1,127,594	1,130,790	1,189,005	1,273,759	1,214,910	1,269,326	1.173,420	1,256.058	13,135,475
1878......	1,203,296	1,094,856	1,208,380	1,195,890	1,264,862	1,217,250	1,283,865	1,341,928	1,315,710	1,369,797	1.348.950	1,318,678	15.163,462
1879......	1,369,921	1,261.935	1,499,315	1,530.450	1,644,922	1,675,650	1,637,767	1,892,302	1.856,700	1,836,378	1.710,480	1,769,356	19.685.176
1880......	1,904,113	1,870,008	2,015,992	2,015,700	2,228,931	2,158,440	2,248,430	2,341,027	2,346,300	2,385,636	2,274,420	2.238,634	26,027,631
1881......	2,244,090	1,913,128	2,274,532	2,205,780	2,393,293	2,377,860	2,372,678	2,331,727	2.193,420	2,323,171	2,266.830	2,480,000	27,376,509
1882......	2,353,551	2,131,332	2,482,170	2,402,790	2,486,572	2,825,940	3,258,162	3,104,495	2,620,380	2,297.658	2,192,940	1,897,510	30,053,500
1883......	1,948,319	1,756,188	1,830,674	1,816,530	1,962,052	1.977,900	2,020,394	1,879,437	1,913,370	2,076,659	1,958,340	1,988,526	23,128,389
1884......	1,825,838	1,880,650	2,052,262	2,065,860	2,381,854	1,862,190	2.059,950	2,099,165	1.948.260	1 961,866	1,811,700	1,822,614	23,772,209
1885......	1,652,176	1,437,884	1,638,133	1,780,290	1,771,371	1,767,210	1.775,804	1,705,961	1,712,790	1,874.105	1,761,660	1,808,657	20,776,041
1886......	1,748,958	1,604,848	1,928,448	1,938,360	2,178,373	2,335,380	2,418,961	2,418,206	2,418,540	2,408,111	2,222,790	2,181,625	25,798,000
1887......	1,990,851	1,827,924	2,007,196	1,960,860	1,993,517	1,912,860	1,899,525	1,848,877	1,779,930	1,843,291	1,125,450	1,288,602	*a*21,478,883
1888......	1,155,937	1,290.718	1,338,877	1,349,403	1,473.362	1,450,703	1,394,847	1,382,077	1,273,080	1,304,518	1,442,405	1,582,741	16,488,668
1889......	1,542,806	1,332,482	1,628,661	1,635,933	1,821,776	1,811,485	1,954,168	1,964,227	1,867,610	1,959,169	1,913,871	2,055,247	21,487,435
1890......	2,108,248	2,055,424	2,313,189	2,328,870	2,378,382	2,370,001	2,524,206	2,514,968	2,584,949	2,750,698	2,575,941	2.626,035	*b*29,130,910
1891......	2,830,081	2,287,320	2,360,011	2,337,498	2,288,656	2,316,988	2,289,089	2,473,398	2,837,562	3,575,911	3,834,262	3,578,460	33,009,236
1892......	2,786,528	2,703,663	2,657,432	2,574,814	2,485,040	2,439,346	2,360,886	2,328,596	2,125,511	2,072,022	1,950,553	1,937,986	28,422,377
1893......	1,723,918	1,671,620	1,900,363	1,682,271	1,763,655	1,780,836	1,720,088	1,691,652	1,614,021	1,616,391	1,533,555	1,616,143	20,314,513
1894......	1,579,420	1,432,251	1,662,595	1,537,500	1,628,149	1,663,964	1,024,767	1,612,212	1,512,116	1,640,982	1,527,752	1,598,282	19,019,990
1895......	1,570,742	1,318,322	1,585,887	1,656,436	1,630,829	1,575,940	1,625,958	1,681,579	1,590,696	1,621,216	1,594,773	1,692,012	19,144,390
1896......	1,648,367	1,517,806	1,632,234	1,842,564	1,746,079	1,784,104	1,853,757	1,726,332	1,699,818	1,746,257	1,642,846	1,744,257	20,584,421
1897......	1,591,700	1,556,488	1,730,502	1,611,633	1,619,548	1,668,286	1,647,363	1,604,954	1,563,483	1,605,362	1,538,117	1,524,630	19,262,066

a Not including 877,310 barrels dump oil and oil shipped by private lines.

b Pipe-line runs.

In the following table is given a statement of the average daily production of crude petroleum in the Pennsylvania and New York oil fields for each month from 1871 to 1897. We desire to repeat that this table is not the same as the daily average receipts published by the pipe lines, but the daily average production, the total production including some oil that is not reported in the daily returns of the pipe lines. The averages are obtained by dividing the product of each month, in the table given elsewhere, by the number of days in each month, and the production of the year by 365 or 366, as the case may be.

Average daily product of crude petroleum in the Pennsylvania and New York oil fields each month for the years 1871–1897, by months and years.

[Barrels.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
1871........	13,497	13,306	12,914	12,866	13,187	13,678	14,725	14,922	15,398	15,653	15,487	15,418	14,261
1872........	18,825	15,965	14,890	15,403	17,326	16,371	16,702	17,739	16,681	14,272	21,287	20,825	17,194
1873........	20,407	21,725	21,461	21,384	25,044	26,449	27,983	30,198	31,809	30,403	33.049	34,980	27,106
1874........	37,653	20,839	28,598	25,958	28,895	30,725	33,337	30,049	28,021	29,669	28,702	27,682	29,937
1875........	27,489	25,708	25,469	22.502	22,468	23,207	25,431	23,186	23,296	23,583	23,340	23.254	24,075
1876........	22,975	23,065	23,167	23,383	23,721	24,120	24,633	25,233	26,020	26,102	26,216	25,390	24,505
1877........	27,190	27,979	29,087	32,427	36,374	37,693	38,335	41,089	40,497	40,946	39,114	40,518	35,988
1878........	38,816	39,102	38,980	39,863	40,802	40,575	41,415	43,288	43,857	44,187	44,965	42,538	41,544
1879........	44,191	43,515	48,365	51,015	53,062	55,855	56,057	61,042	61,890	59,238	57,016	57,076	54,206
1880........	61,423	64,552	65,032	67,190	71,901	71,948	72,530	75,517	78,210	76,956	75,814	72,214	71,114
1881........	72,390	68,326	73,372	73,526	77,203	79,262	76,538	75,217	73,114	74,941	75,561	80,000	75,004
1882........	75,921	76,119	80,070	80,093	80,212	94,198	105,102	100,145	87,346	74,118	73,098	61,210	82,338
1883........	62,849	62.721	59,054	60,551	63,292	65.930	65,174	60,627	63,779	66,989	65,278	64,146	63,365
1884........	58,898	64,850	66,202	68,862	76,834	62,073	66,450	67.715	64,942	63,286	60,390	58,794	65,129
1885........	53.296	51,353	52,843	59,343	59,141	58,907	57,284	55.031	57,093	60,455	58,722	61,247	56,921
1886........	56,418	57,316	62,208	64.612	70,283	77,846	78,031	78,426	80,618	77,681	74,093	70,375	70,679
1887........	64,221	65,283	64,716	65,372	64,307	63,762	61,275	59,641	59,321	61,822	37,515	41,568	58,846
1888........	37,228	44,508	43,190	44,980	47.528	48,357	44,995	44,661	42,436	43,694	48,080	51,057	45,058
1889........	49,768	47,589	52,537	54,531	58,767	60,382	63,037	63,362	62,254	63,199	63,796	66,298	58,869

Average daily product of crude petroleum in the Pennsylvania and New York oil fields each month for the years 1871-1897, by months and years—Cont'd.

[Barrels.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
1890........	68,008	73,408	74,619	77,629	76,722	79,000	81,426	81,128	86,165	88,732	85,865	84,710	79,810
1891........	91,293	81,690	76,129	77,917	73,828	77,233	73,842	79,787	94,585	115,352	127,809	115,434	90,436
1892........	89,888	93,230	85,724	85,827	80,163	81,312	76,158	75,116	70,850	66,839	65,018	62,516	77,657
1893........	55,610	59,701	61,302	56,076	56,505	59,361	55,487	54,569	53,801	52,142	51,119	52,133	55,656
1894........	50,949	51,152	53,632	51,250	52,521	55,465	52,412	52,007	50,404	52,935	50,925	51,557	52,110
1895........	50,669	47,083	51,093	55,215	52,607	52,531	52,450	54,244	53,023	52,299	53,159	54,581	52,450
1896........	53,173	52,338	52,653	61,419	56,325	59,470	59,799	55,688	56,661	56,331	54,762	56,266	56,241
1897........	51,345	55,589	55,823	53,721	52,243	55,610	53,141	51,773	52,116	51,786	51,270	49,182	52,773

SHIPMENTS OF PETROLEUM FROM PENNSYLVANIA, NEW YORK, AND WEST VIRGINIA.

The following table gives the number of barrels of crude petroleum shipped out of New York, Pennsylvania, and West Virginia either by pipe lines, railways, or river, from 1871 to 1897, inclusive:

Shipments of crude and refined petroleum, reduced to crude equivalent, out of the Pennsylvania, New York, and West Virginia oil fields from 1871 to 1897, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1871......	437,691	347,718	383,890	389,147	587,375	501,754	541,137	528,134	551,075	505,071	480,977	410,822	5,664,791
1872......	476,966	407,606	276,220	428,512	510,417	529,228	591,238	621,954	541,607	607,468	477,945	430,786	5,899,947
1873......	573,124	527,440	668,374	708,191	768,176	696,414	814,449	864,768	952,955	1,010,852	959,589	955,443	9,499,775
1874......	843,663	501,220	518,246	803,409	899,027	815,413	940,281	793,865	1,014,570	543,341	546,117	602,348	8,821,500
1875......	453,095	327,776	693,918	729,581	681,679	745,986	904,537	882,089	1,109,392	871,917	671,066	871,902	8,942,938
1876......	677,289	519,193	623,762	603,037	646,150	921,862	1,228,539	1,203,402	1,154,549	524,190	871,496	1,190,983	10,164,452
1877......	743,461	484,904	913,919	903,526	1,234,324	1,391,124	1,096,951	1,425,943	1,563,797	1,268,971	1,205,634	600,019	12,832,573
1878......	775,791	774,234	741,512	846,632	960,894	1,135,119	1,330,454	1,655,651	1,434,225	1,747,390	1,281,410	992,688	13,676,000
1879......	663,998	702,729	973,879	1,136,188	1,331,469	1,369,314	1,625,035	1,808,239	1,627,120	1,662,269	1,453,645	1,532,585	15,886,470
1880......	1,650,409	1,395,151	1,618,371	842,268	1,095,259	975,088	1,231,611	1,394,129	1,252,635	1,665,938	1,226,030	1,335,613	15,677,492
1881......	1,061,617	915,028	1,276,746	1,348,398	1,563,436	1,729,697	1,925,532	2,214,877	2,131,950	2,080,467	2,066,906	1,969,581	20,284,235
1882......	1,657,067	1,787,909	1,718,956	1,678,134	1,827,356	2,172,685	2,402,970	2,047,545	1,992,171	2,089,428	1,404,640	1,121,453	21,900,314
1883......	1,357,815	1,250,824	1,641,899	1,908,379	1,995,634	1,747,789	1,634,407	2,086,478	2,325,574	2,215,421	2,065,602	1,749,547	21,979,369
1884......	1,686,961	1,723,261	1,873,890	1,643,336	1,899,329	1,827,553	1,740,021	2,000,371	2,292,087	2,510,283	2,078,261	2,382,244	23,657,597
1885......	1,804,028	1,895,021	1,887,034	1,823,726	2,097,099	2,034,025	1,961,152	2,049,099	2,116,659	2,050,150	1,857,080	2,138,253	23,713,326
1886......	1,991,561	2,032,794	2,055,750	2,070,468	2,032,672	2,117,489	2,418,961	2,059,299	2,157,323	2,441,848	2,724,796	2,550,891	26,653,852
1887......	2,312,067	1,995,757	2,332,324	1,938,278	2,328,564	2,165,439	2,000,173	2,220,768	2,342,227	2,573,008	3,462,082	2,608,341	27,279,028
1888......	2,265,109	2,163,957	1,979,753	1,928,435	1,773,994	1,956,115	2,098,531	2,223,263	2,289,486	1,558,115	2,503,491	2,397,782	25,138,031
1889......	2,388,609	2,272,060	2,263,009	2,236,004	2,256,122	2,268,280	2,949,597	2,625,825	2,567,459	2,747,284	2,393,131	2,671,518	29,638,892
1890......	2,637,339	2,146,108	2,148,977	2,317,410	2,474,966	2,486,205	2,640,668	2,538,224	2,648,418	2,725,341	2,662,898	2,689,521	30,116,075
1891......	2,421,419	2,143,611	2,429,664	2,155,511	2,072,139	2,122,085	2,260,176	2,496,255	2,701,461	2,799,214	2,601,434	2,781,530	28,984,400
1892......	2,418,231	2,441,346	2,584,312	2,336,821	2,277,775	2,070,396	2,312,571	2,624,488	2,738,369	2,820,735	2,911,907	2,972,479	30,539,430

Shipments of crude and refined petroleum, reduced to crude equivalent, out of the Pennsylvania, New York, and West Virginia oil fields from 1871 to 1897, by months and years—Continued.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1893......	2,950,184	2,578,185	2,835,719	2,660,292	3,031,362	3,073,319	3,318,633	3,248,280	2,998,775	3,314,390	3,092,030	3,149,675	36,250,859
1894......	3,138,356	2,652,065	2,909,720	2,844,534	2,817,415	2,913,440	2,924,466	3,254,087	2,963,025	3,266,904	3,204,296	3,282,089	36,170,481
1895......	3,136,494	2,805,695	2,605,078	2,780,249	2,844,465	2,814,942	2,634,296	2,422,969	2,330,147	2,569,738	2,648,609	2,406,751	31,999,433
1896......	2,539,390	2,249,302	2,437,026	2,226,204	2,417,564	2,248,761	2,540,332	2,404,063	2,542,363	2,602,853	2,499,474	2,611,511	29,318,843
1897......	2,535,553	2,309,050	2,771,647	2,451,242	2,546,296	2,554,516	2,707,317	3,098,793	2,953,713	3,634,805	3,316,574	2,761,749	33,641,255

In the early history of the oil business a very large percentage of the crude oil went direct from the field to the refineries, either by wagon, boat, or railway, and was lost sight of until shipped as refined oil, which was reduced to the equivalent of crude petroleum by allowing one barrel of crude to produce three-fourths of a barrel of refined, or a barrel of refined was regarded as being the equivalent of one and one-third barrels of crude. Since 1888 nearly the entire amount of crude petroleum has passed through the pipe lines, and is given under the head of shipments from the Appalachian field by months.

DRILLING WELLS COMPLETED IN PENNSYLVANIA, NEW YORK, WEST VIRGINIA, AND THAT PART OF OHIO INCLUDED IN THE SOUTHWESTERN FIELD.

In the early history of the production of petroleum almost all of it came from New York and Pennsylvania. In after years oil was found in Ohio near Macksburg and Marietta, and on the Little Kanawha River in West Virginia. These points were so far isolated that it was not difficult to keep them separated, so for a number of years there was a correct table of wells drilled in Pennsylvania and New York. Now it is almost one continuous field from western New York to the Little Kanawha River of West Virginia, a part extending over into Ohio from West Virginia at and near Sistersville, on the Ohio River, and the following table includes the wells drilled in this portion of Ohio.

To obtain the totals of all wells drilled in the Appalachian field we would have to add to this table those comprised under the head of the southern Ohio district, which are shown in a table given on a previous page:

Number of drilling wells completed in the Pennsylvania, New York, West Virginia, and a part of Ohio oil fields each month from 1872 to 1897.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec.	Total.
1872 ..	37	120	89	121	135	84	128	118	82	100	64	105	1, 183
1873 ..	93	94	100	105	102	130	114	120	106	101	100	98	1, 263
1874 ..	102	104	110	113	109	101	121	107	104	120	106	120	1, 317
1875 ..	190	187	195	186	172	190	200	210	201	220	217	230	2, 398
1876 ..	240	231	242	200	202	261	248	270	209	273	272	272	2, 920
1877 ..	281	241	291	269	320	403	317	255	322	467	391	382	3, 929
1878 ..	274	226	211	409	470	269	203	186	174	229	248	165	3, 064
1879 ..	136	132	238	270	402	330	327	283	210	232	227	261	3, 048
1880 ..	320	230	367	500	426	310	338	368	356	364	336	302	4, 217
1881 ..	222	220	271	316	406	374	336	332	312	322	363	406	3, 880
1882 ..	347	340	385	432	469	340	185	253	164	117	150	122	3, 304
1883 ..	125	126	142	209	231	228	261	309	321	321	302	272	2, 847
1884 ..	229	227	256	298	311	244	268	145	89	59	73	66	2, 265
1885 ..	64	62	82	116	213	242	217	283	356	397	384	345	2, 761

Number of drilling wells completed in the Pennsylvania, New York, West Virginia, and a part of Ohio oil fields each month from 1873 to 1897—Continued.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1886 ..	270	280	291	328	343	365	357	313	253	272	221	185	3,478
1887 ..	158	162	138	160	148	162	159	142	134	100	101	96	1,660
1888 ..	57	52	56	49	56	97	82	96	132	229	307	302	1,515
1889 ..	284	288	353	401	431	537	549	508	478	559	540	471	*a*5,435
1890 ..	553	482	522	556	534	571	555	579	571	567	520	348	6,358
1891 ..	310	243	275	288	314	304	334	333	281	237	245	197	3,361
1892 ..	175	171	137	167	170	154	174	141	142	158	160	143	1,892
1893 ..	125	84	130	127	172	213	193	145	158	139	137	167	1,790
1894 ..	180	170	202	261	307	349	319	341	362	373	368	316	3,548
1895 ..	271	195	324	425	601	754	772	766	735	686	613	534	6,676
1896 ..	537	514	499	569	658	744	673	589	594	581	622	625	7,205
1897 ..	544	408	368	428	485	553	603	557	455	417	404	352	5,574

a Includes 36 wells drilled in Franklin district, data for which by months was not obtainable.

WEST VIRGINIA.

The developments in this State in 1897 have been described under the head of Appalachian extension. It is the production in this State that has held up the production of the Appalachian field, in which Pennsylvania and Ohio showed a decrease. The percentage of increase was greater in 1897 than it was in 1896,.being 30.64 per cent in 1897 and 23.39 per cent in 1896. The increase has doubled nine times in ten years, notwithstanding the deep wells required in most of the fields of this State, and the decrease in the average price, which was 78¾ cents in 1897, as compared with $1.18 in 1896.

The Elk Fork pool added 1,504,290 barrels during the year, and in it there was a decided falling off toward the close of 1897, which, according to indications, will not be replaced by the production of the Whiskey Run pool, opened just about the close of the year.

The production of a very high grade of natural lubricating oil along the west flank of the great anticline near the central part of the basin continued in 1897. There was a falling off of 1,770 barrels, as compared with 1896, in the production of lubricating petroleum.

The production of crude petroleum in West Virginia, by months, from 1890 to 1897 is shown in the following table:

Total production of crude petroleum in West Virginia, by months, from 1890 to 1897.

[Barrels.]

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	38, 644	48, 902	195, 512	577, 933	838, 400	647, 220	757, 574	869, 210
February	38, 061	123, 841	186, 455	468, 794	684, 532	541, 511	729, 229	844, 833
March	44, 842	229, 966	185, 468	630, 877	754, 398	642, 222	785, 261	938, 673
April	39, 804	226, 020	181, 708	594, 190	688, 458	646, 862	799, 509	942, 252
May	39, 160	232, 076	206, 142	705, 714	742, 701	670, 330	855, 699	1, 016, 213
June	35, 610	223, 734	261, 900	682, 040	699, 498	621, 733	853, 224	1, 063, 053
July	34, 096	221, 127	328, 485	724, 494	767, 728	742, 326	843, 872	1, 142, 045
August	31, 505	238, 451	411, 114	813, 706	717, 844	734, 517	874, 595	1, 283, 358
September	50, 342	219, 528	420, 882	847, 558	674, 791	717, 170	876, 308	1, 254, 770
October	46, 387	220, 076	451, 157	792, 719	694, 187	713, 138	884, 716	1, 269, 522
November	45, 062	207, 477	467, 446	757, 170	654, 887	721, 411	851, 488	1, 261, 766
December	49, 065	215, 020	513, 817	820, 217	660, 200	721, 685	908, 295	1, 204, 350
Total	492, 578	2, 406, 218	3, 810, 086	8, 445, 412	8, 577, 624	8, 120, 125	10, 019, 770	13, 090, 045

In the following table is given the production of crude petroleum in West Virginia in the years 1894, 1895, 1896, and 1897, by districts:

Total amount and value of petroleum produced in West Virginia in 1894, 1895, 1896, and 1897.

District.	1894.								
	Regular crude.			Lubricating crude.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia	8, 553, 046	$7, 173, 867	$0. 83⅞	....	....	....	8, 553, 046	$7, 173, 867	$0. 83⅞
Volcano	2, 560	2, 176	. 85	12, 000	$36, 000	$3. 00	14, 560	38, 176	2. 62
Petroleum	8, 348	6, 751	. 80⅞	1, 670	2, 923	1: 75	10, 018	9, 674	. 96½
Total	8, 563, 954	7, 182, 794	. 83⁹⁄₁₀	13, 670	38, 923	2. 85	8, 577, 624	7, 221, 717	. 84

District.	1895.								
	Regular crude.			Lubricating crude.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia	8, 105, 341	$11, 013, 132	$1. 35⅞	....	....	....	8, 105, 341	$11, 013, 132	$1. 35⅞
Volcano	260	338	1. 30	9, 910	$19, 820	$2. 00	10, 170	20, 158	1. 98
Petroleum	4, 181	4, 181	1. 00	433	1, 299	3. 00	4, 614	. 5, 480	1. 19
Total	8, 109, 782	11, 017, 651	1. 35⁴⁄₇	10, 343	21, 119	2. 04	8, 120, 125	11, 038, 770	1. 36

Total amount and value of petroleum produced in West Virginia in 1894, 1895, 1896, and 1897—Continued.

District.	1896.								
	Regular crude.			Lubricating crude.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia	10,005,966	$11,794,532	$1.17⅞	....	....	....	10,005,966	$11,794,532	$1.17⅞
Volcano	....	....	....	13,228	$33,070	$2.50	13,228	33,070	2.50
Petroleum	....	....	....	576	2,016	3.50	576	2,016	3.50
Total	10,005,966	11,794,532	1,17⅞	13,804	35,086	2.54	10,019,770	11,829,618	1.18

District.	1897.								
	Regular crude.			Lubricating crude.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia	13,078,011	$10,282,586	$0.78⅝	....	....	....	13,078,011	$10,282,586	$0.78⅝
Volcano	....	....	....	11,622	$26,150	$2.25	11,622	26,150	2.25
Petroleum	....	....	....	412	1,442	3.50	412	1,442	3.50
Total	13,078,011	10,282,586	.78⅝	12,034	27,592	2.29	13,090,045	10,310,178	.78¾

In the following table is given the production of oil in West Virginia from the beginning of operations, so far as obtainable, that previous to 1877 being partially estimated:

Production of petroleum in West Virginia.

Year.	Barrels.	Year.	Barrels.
Previous to 1876	3,000,000	1888	119,448
1876	120,000	1889	544,113
1877	172,000	1890	492,578
1878	180,000	1891	2,406,218
1879	180,000	1892	3,810,086
1880	179,000	1893	8,445,412
1881	151,000	1894	8,577,624
1882	128,000	1895	8,120,125
1883	126,000	1896	10,019,770
1884	90,000	1897	13,090,045
1885	91,000	Total	60,289,419
1886	102,000		
1887	145,000		

OHIO.

This State has a part of two fields of petroleum. The Appalachian field extends along its southeastern border from Steubenville to Corning, this portion being known as the southern or southeastern Ohio field. The Mecca and Belden districts are outliers to the north of this field and produce a small amount of superior natural lubricating petroleum. The other field is known as the Lima field, located in the northwestern portion of the State.

In the Appalachian field the oil comes from sands which occupy several positions in the vertical scale. The principal sources are, however, the productive Coal Measures, the Lower Conglomerates, the Waverly, and the sands of the upper portion of the Ohio shale of the Devonian formation.

In the Lima field the source of the crude petroleum is the upper portion of the Trenton limestone. The interval of horizontal strata between the lowest productive sand of the upper oil sands and the Trenton varies from 3,200 to 5,000 feet. There is a very great difference in the character of these oils found in the southeastern Ohio field, which vary from a light amber to a very dark green.

The Lima oil contains a percentage of sulphureted hydrogen, which gives to it a peculiar odor, and is dark in color—yellow by transmitted light and dark green by reflected light. The oils of southern Ohio are free from this odor and are generally of lighter color and lighter gravity. Some of the intervening sands and limestones between the upper

Devonian and the Trenton have produced oil, but not in paying quantities. The total crude petroleum produced in Ohio in both fields in 1897 was 21,560,515 barrels. There was a decrease of 2,380,654 barrels as compared with 1896, amounting to nearly 11½ per cent. In 1897, 2,877,193 barrels came from the Appalachian or southeastern portion of Ohio, 645 barrels from the Mecca Belden division of the same field, and 18,682,677 barrels from the Lima field, the latter being 87 per cent of the total production of the State. The production in the Lima field in Ohio in 1896 was 20,575,138 barrels, showing a decrease of 9.2 per cent during the year 1897. The price in the State declined from a general average in 1896 of about $0.74 to $0.52 in 1897, equal to a decrease of 22 cents, or 30 per cent. The number of wells completed in Ohio in 1897 was 2,998, as compared with 5,077 in 1896, a decrease of 41 per cent. These figures show that the production held up remarkably when the decrease in the number of wells completed and the decrease in the price is considered.

Wood County has continued to hold the lead in the new work during the year. There were several small pools opened up in this county. Lucas County also showed a considerable amount of new territory during the year.

There is considerable territory in this field that can insure moderately good wells, if the price were increased sufficiently to encourage new work.

PRODUCTION.

The total amount and value of crude petroleum produced in Ohio in all fields in 1896 and 1897 are shown in the following table:

Total amount and value of crude petroleum produced in Ohio in 1896 and 1897.

District.	1896.			1897.		
	Total production.	Total value.	Price per barrel.	Total production.	Total value.	Price per barrel.
	Barrels.			*Barrels.*		
Lima	20,575,138	$13,723,617	$0.667	18,682,677	$8,967,685	$0.48
Eastern	3,365,365	3,966,924	1.17⅞	2,877,193	2,262,193	.78⅝
Mecca-Belden	666	2,897	4.35	645	3,120	4.84
Total.	23,941,169	17,693,438	.739	21,560,515	11,232,998	.52

In the following table will be found the total production of all the crude petroleum in Ohio in 1897, by months, in the several fields. The production in the Mecca-Belden field, being very small, was not divided into monthly production:

Total production of crude petroleum in Ohio in 1897, by months and districts.

[Barrels of 42 gallons.]

Month.	Lima.	Southeastern Ohio.	Mecca-Belden.	Total.
January	1,534,285	293,801	....	1,828.136
February	1,485,039	262,035	....	1,747,124
March	1,638,755	266,343	....	1,905,148
April	1,570,621	255,213	....	1,825,884
May	1,590,956	266,760	....	1,857,766
June	1,589,063	259,100	....	1,848,213
July	1,608,730	245,876	....	1,854,656
August	1,603,336	227,013	....	1,830,399
September	1,546,131	217,018	....	1,763,199
October	1,571,760	203,127	....	1,774,937
November	1,458,688	183,683	....	1,642,421
December	1,485,313	197,224	....	1,682,632
Total	18,682,677	2,877,193	645	21,560,515

The total amount and value of crude petroleum produced in Ohio from 1889 to 1897, inclusive, by districts, are shown in the following table:

Total amount and value of crude petroleum produced in Ohio from 1889 to 1897.

Year.	Lima district.		Southeastern Ohio district.		Mecca-Belden district.		Total.	
	Production.	Value.	Production.	Value.	Production.	Value.	Production.	Value.
	Barrels.		*Barrels.*		*Barrels.*		*Barrels.*	
1889	12,153,189	$1,822,978	317,037	$340,683	1,240	$10,334	12,471,466	$2,173,995
1890	15,014,882	4,504,465	1,108,334	1,127,730	1,440	12,000	16,124,656	5,644,195
1891	17,315,978	5,281,373	422,883	283,332	1,440	12,000	17,740,301	5,576,705
1892	15,169,507	5,555,832	1,190,302	662,106	3,112	21,101	16,362,921	6,239,039
1893	13,646,804	6,448,115	2,601,394	1,664,892	1,571	11,335	16,249,769	8,124,342
1894	13,607,844	6,531,765	3,183,370	2,670,052	940	4,476	16,792,154	9,206,293
1895	15,850,609	11,372,812	3,693,248	5,018,201	1,376	8,229	19,545,233	16,399,242
1896	20,575,138	13,723,617	3,365,365	3,966,924	666	2,897	23,941,169	17,693,438
1897	18,682,677	8,967,685	2,877,193	2,262,193	645	3,120	21,560,515	11,232,998

In the following table is given the total production of crude petroleum in Ohio for the years 1888 to 1897, by months:

Total production of crude petroleum in Ohio from 1888 to 1897, by months.

[Barrels.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1888	444, 804	507, 686	612, 830	656, 186	774, 267	889, 066	939, 287	1, 022, 009	1, 005, 422	1, 064, 688	1, 017, 362	1, 077, 261	10, 010, 868
1889	1, 041, 655	944, 506	1, 016, 278	1, 029, 780	1, 115, 703	1, 074, 384	1, 052, 430	1, 075, 008	1, 060, 982	1, 048, 448	1, 030, 795	981, 497	12, 471, 466
1890	948, 780	929, 810	1, 008, 933	1, 101, 773	1, 223, 241	1, 274, 209	1, 472, 974	1, 544, 291	1, 700, 227	1, 798, 413	1, 608, 883	1, 513, 122	16, 124, 656
1891	1, 561, 039	1, 396, 474	1, 484, 045	1, 500, 142	1, 475, 339	1, 516, 362	1, 545, 298	1, 538, 210	1, 523, 826	1, 527, 490	1, 299, 737	1, 372, 339	17, 740, 301
1892	1, 124, 194	1, 160, 634	1, 242, 936	1, 173, 952	1, 216, 416	1, 266, 712	1, 370, 135	1, 572, 657	1, 574, 336	1, 586, 173	1, 517, 198	1, 557, 578	16, 362, 921
1893	1, 227, 363	1, 195, 698	1, 399, 648	1, 289, 982	1, 384, 090	1, 419, 758	1, 444, 572	1, 480, 285	1, 402, 213	1, 397, 125	1, 306, 883	1, 302, 152	16, 249, 769
1894	1, 326, 282	1, 187, 891	1, 431, 894	1, 368, 268	1, 486, 678	1, 439, 144	1, 398, 304	1, 487, 528	1, 369, 409	1, 469, 457	1, 424, 926	1, 402, 373	16, 792, 154
1895	1, 286, 468	1, 123, 784	1, 387, 882	1, 480, 228	1, 572, 718	1, 590, 936	1, 779, 452	1, 877, 470	1, 904, 985	1, 963, 297	1, 840, 501	1, 737, 512	19, 545, 233
1896	1, 957, 875	1, 805, 698	1, 967, 188	1, 989, 262	2, 062, 582	2, 101, 507	2, 117, 849	2, 059, 532	1, 994, 503	2, 041, 301	1, 863, 720	1, 980, 152	23, 941, 169
1897	1, 828, 136	1, 747, 124	1, 905, 148	1, 825, 884	1, 857, 766	1, 848, 213	1, 854, 656	1, 830, 399	1, 763, 199	1, 774, 937	1, 642, 421	1, 682, 632	21, 560, 515

The following table gives the production of petroleum in Ohio from the beginning of operations in that State to the close of 1897:

Production of petroleum in Ohio.

Year.	Barrels.	Year.	Barrels.
Previous to 1876	200,000	1887	5,022,632
1876	31,763	1888	10,010,868
1877	29,888	1889	12,471,466
1878	38,179	1890	16,124,656
1879	29,112	1891	17,740,301
1880	38,940	1892	16,362,921
1881	33,867	1893	16,249,769
1882	39,761	1894	16,792,154
1883	47,632	1895	19,545,233
1884	90,181	1896	23,941,169
1885	661,580	1897	21,560,515
1886	1,782,970		

LIMA DISTRICT.

The first petroleum discovered in the Lima (Ohio) district was produced by a well drilled at Findlay, Hancock County, in the fall of 1884. The production almost doubled in that year. It was 1885, however, that increased the production 734 per cent over 1884. As this district is now by far the most important field at present in Ohio, it will be considered first, and that portion of the Appalachian field inside of the State of Ohio will be then taken up.

PRODUCTION.

The following table gives the production of this district, beginning with 1886 and ending in 1897:

Production of petroleum in the Lima (Ohio) district from 1886 to 1897.

Year.	Barrels.	Year.	Barrels.
1886	1,064,025	1892	15,169,507
1887	4,650,375	1893	13,646,804
1888	9,682,683	1894	13,607,844
1889	12,153,189	1895	15,850,609
1890	15,014,882	1896	20,575,138
1891	17,315,978	1897	18,682,677

In the following table is found the production of petroleum in the Lima (Ohio) field from 1887 to 1897, by months, so far as it has been obtainable:

Production of petroleum in the Lima (Ohio) field from 1887 to 1897.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1887	131, 011	206, 026	303, 084	352, 798	449, 062	474, 535	389, 997	490, 862	465, 743	444, 941	458, 612	483, 704	4, 650, 375
1888	422, 125	479, 824	586, 781	629, 932	745, 896	862, 106	905, 218	995, 938	979, 943	1, 036, 712	988, 997	1, 049, 211	9, 682, 683
1889	1, 016, 697	921, 185	989, 793	1, 004, 969	1, 090, 638	1, 050, 269	1, 029, 707	1, 050, 152	1, 038, 072	1, 019, 961	997, 825	943, 921	12, 153, 189
1890	911, 947	888, 978	955, 620	1, 040, 924	1, 142, 954	1, 175, 821	1, 354, 672	1, 411, 998	1, 559, 473	1, 660, 069	1, 495, 099	1, 417, 327	15, 014, 882
1891	1, 471, 858	1, 355, 734	1, 455, 628	1, 470, 661	1, 446, 284	1, 491, 228	1, 514, 607	1, 509, 262	1, 492, 115	1, 499, 834	1, 271, 189	1, 337, 578	17, 315, 978
1892	1, 090, 173	1, 127, 481	1, 200, 305	1, 128, 253	1, 165, 750	1, 210, 523	1, 300, 197	1, 461, 020	1, 422, 534	1, 379, 909	1, 328, 548	1, 354, 814	15, 169, 507
1893	1, 037, 358	985, 620	1, 161, 384	1, 072, 850	1, 179, 808	1, 213, 521	1, 231, 010	1, 258, 289	1, 181, 493	1, 154, 641	1, 084, 324	1, 086, 506	13, 646, 804
1894	1, 116, 979	974, 091	1, 177, 837	1, 099, 452	1, 203, 229	1, 165, 190	1, 131, 081	1, 212, 090	1, 090, 626	1, 165, 938	1, 146, 686	1, 124, 644	13, 607, 844
1895	1, 034, 489	900, 530	1, 111, 346	1, 194, 799	1, 287, 167	1, 300, 058	1, 474, 115	1, 540, 149	1, 527, 085	1, 579, 693	1, 494, 985	1, 406, 193	15, 850, 609
1896	1, 635, 925	1, 523, 866	1, 673, 595	1, 697, 848	1, 775, 858	1, 822, 817	1, 843, 477	1, 789, 341	1, 739, 122	1, 770, 493	1, 612, 298	1, 690, 498	20, 575, 138
1897	1, 534, 285	1, 485, 039	1, 638, 755	1, 570, 621	1, 590, 956	1, 589, 063	1, 608, 730	1, 603, 336	1, 546, 131	1, 571, 760	1, 458, 688	1, 485, 313	18, 682, 677

WELL RECORDS IN THE LIMA DISTRICT.

In the following tables will be found statements showing the well records in the Lima (Ohio) district from 1894 to 1897, inclusive.

The table below shows the wells completed each month during the year 1897 in the Lima (Ohio) field:

Total number of wells completed in the Lima (Ohio) district in 1897.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January ...	23	24	54	24	76	11	1	11	28	252
February ..	22	15	44	18	63	8	4	7	12	193
March	20	17	41	28	69	12	1	3	19	210
April	23	27	41	37	56	7	2	5	17	215
May	22	25	32	40	58	15	1	3	30	226
June.......	15	30	35	28	67	8	0	4	24	211
July	16	26	39	22	102	9	2	4	22	242
August.....	12	33	17	13	77	10	0	3	28	193
September .	13	35	22	18	71	16	1	2	38	216
October....	16	33	40	11	57	11	0	2	26	196
November .	17	21	41	11	56	9	0	5	31	191
December ..	13	17	26	8	39	2	2	4	30	141
Total ..	212	303	432	258	791	118	14	53	305	2,486

In the following table it will be seen that the average of the initial daily production of the new wells in 1897 was 4,818 barrels per month. This amount multiplied by 12 gives 57,816 as the total initial production. This divided by 2,102, the number of wells less the dry holes, gives 27 as the average number of barrels of initial daily production for each paying well drilled in 1897, as compared with 21.7 in 1896 and 23 in 1895. The declining price decreased the number of wells drilled, and they were more carefully selected as to paying territory in 1897 as compared with 1896, and therefore show a greater initial production.

Initial daily production of wells completed in the Lima (Ohio) district in 1897.

[Barrels.]

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January ...	475	475	780	390	1,390	200	30	185	785	4,710
February ..	390	450	655	360	1,205	150	40	95	255	3,600
March	435	680	665	420	2,080	165	10	15	350	4,820
April	400	560	455	605	1,285	150	5	55	525	4,040
May	300	550	925	735	960	180	10	45	470	4,175
June	270	880	475	360	1,920	120	0	30	470	4,525
July	245	1,020	460	355	2,825	200	45	25	680	5,855
August	200	2,405	580	180	1,945	340	0	15	1,075	6,740
September .	190	2,495	400	385	1,418	190	30	20	1,155	6,283
October	345	1,650	1,290	275	1,085	125	0	40	1,145	5,955
November ..	170	645	820	225	990	70	0	110	1,115	4,145
December ..	160	520	225	70	920	45	0	75	960	2,975
Average...	298	1,028	644	363	1,502	161	14	59	749	4,818

It will be seen by the following table that there were 384 dry holes completed in 1897, as compared with 550 in 1896. This leaves 2,102 producing wells in 1897, as compared with 3,908 producing wells drilled in 1896. This is a decrease of 46 per cent in the number of producing wells, while the production only decreased 9.2 per cent.

Total number of dry holes drilled in the Lima (Ohio) district in 1897.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January	3	7	4	1	6	3	0	0	4	28
February ..	5	4	5	0	9	2	1	1	1	28
March	3	3	5	3	10	3	0	0	3	30
April	5	8	6	1	8	3	1	0	0	32
May	2	5	1	4	6	5	0	0	8	31
June	2	5	5	2	8	1	0	0	2	25
July	3	1	7	2	15	1	0	0	7	36
August.....	3	4	3	3	11	0	0	1	1	26
September .	3	4	3	1	14	6	0	0	2	33
October	5	4	12	0	11	4	0	0	3	39
November ..	7	8	11	0	8	4	0	3	2	43
December ..	2	6	11	2	8	0	2	1	1	33
Total	43	59	73	19	114	32	4	6	34	384

The number of rigs building indicates the operations at the close of the year, from which time the number usually declines, owing to severe weather. The average for the year 1897 was 90 per month, as compared with an average of 159 per month in 1896. This is an average decrease of 43½ per cent.

Total number of rigs building in the Lima (Ohio) district in 1897.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January....	4	1	12	16	44	5	3	3	6	94
February ..	6	6	12	21	43	6	3	2	9	108
March	2	4	13	24	42	5	3	2	7	102
April	2	13	5	21	34	5	3	1	13	97
May	2	8	14	17	40	7	3	1	8	100
June.......	2	6	10	13	44	2	3	3	11	94
July	0	5	8	15	34	7	3	0	4	76
August.....	2	9	9	12	29	4	3	1	10	79
September .	1	5	15	13	27	2	3	0	5	71
October	5	9	12	13	30	2	3	2	9	85
November..	3	7	10	15	34	3	4	1	11	88
December..	2	15	7	16	29	1	3	1	8	82
Average..	3	7	11	16	36	4	3	1	9	90

The following table shows 128 wells drilling at the close of the year as compared with 249 wells at the close of 1896:

Total number of wells drilling in the Lima (Ohio) district in 1897.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January ...	23	18	51	19	65	8	4	6	23	217
February ..	15	14	45	23	81	12	1	1	29	221
March	15	24	41	20	62	8	1	1	28	200
April	16	21	29	20	57	15	1	2	26	187
May	8	16	27	16	53	5	0	2	21	148
June.......	12	14	38	15	71	12	0	1	26	189
July	10	20	20	15	61	5	0	2	27	160
August.....	12	30	20	13	62	12	1	0	34	184
September .	10	24	35	8	59	7	1	2	22	168
October	11	18	42	7	51	12	1	3	33	178
November..	15	12	30	6	41	5	1	3	28	141
December..	8	13	24	6	44	8	0	0	25	128
Average..	13	19	33	14	59	9	1	2	27	177

Number of wells completed in the Lima (Ohio) district from 1890 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890..	44	62	.....	.....	147	165	224	271	307	319	243	187	1,969
1891..	142	123	129	156	116	143	144	138	157	134	104	88	1,574
1892..	67	82	93	93	93	121	134	166	171	174	147	105	1,446
1893..	100	85	163	135	128	160	152	133	131	120	132	130	1,569
1894..	130	175	179	205	248	230	233	219	204	226	214	209	2,472
1895..	200	158	244	316	412	461	484	519	462	427	470	336	4,489
1896..	328	355	370	432	504	513	396	337	346	279	299	299	4,458
1897..	252	193	210	215	226	211	242	193	216	196	191	141	2,486

Initial daily production of new wells in the Lima (Ohio) district from 1890 to 1897, by months.

[Barrels.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890............	....	....	....	....	....	....	....	18,944	16,309	17,426	13,779	8,424	14,976
1891............	5,858	5,474	4,428	6,543	4,411	6,667	8,461	8,427	7,855	8,033	5,592	2,989	6,228
1892............	2,853	4,485	3,973	4,665	4,750	8,314	11,648	14,631	12,908	13,772	7,554	4,907	7,872
1893............	5,510	4,809	6,241	5,477	6,858	9,701	9,588	5,124	6,752	4,223	4,205	3,275	5,980
1894............	3,853	4,211	4,486	5,586	7,291	6,391	5,637	5,642	5,020	5,991	10,464	5,539	5,843
1895............	4,432	3,753	5,281	6,208	8,161	9,772	9,011	10,025	9,175	8,586	9,695	6,284	7,532
1896............	5,651	6,704	7,885	9,335	9,902	9,670	6,885	6,175	5,640	5,355	5,630	6,171	7,084
1897............	4,710	3,600	4,820	4,040	4,175	4,525	5,855	6,740	6,283	5,955	4,145	2,975	4,818

Total number of dry holes drilled in the Lima (Ohio) district from 1890 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890..	3	2	.....	.....	4	11	10	23	30	32	37	41	193
1891..	28	27	23	28	14	18	22	14	26	20	17	13	250
1892..	9	9	8	13	10	18	16	18	27	22	18	15	183
1893..	12	15	20	24	18	19	18	12	14	16	13	22	203
1894..	17	41	37	27	32	41	30	34	35	27	28	35	384
1895..	33	19	38	33	66	65	70	48	59	48	49	36	564
1896..	43	44	57	39	55	63	47	35	52	26	42	47	550
1897..	28	28	30	32	31	25	36	26	33	39	43	33	384

Number of wells drilling in the Lima (Ohio) district, at the close of each month, from 1890 to 1897.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890..	47	59	.....	.....	135	188	237	182	238	294	148	111	164
1891..	90	105	94	82	79	90	90	93	85	88	67	53	85
1892..	61	78	76	51	64	95	101	112	120	114	106	81	88
1893..	72	78	88	92	117	119	103	101	89	102	118	114	99
1894..	120	113	127	138	127	139	117	138	136	136	138	140	131
1895..	132	176	214	269	302	369	397	413	404	435	306	331	312
1896..	327	317	338	368	371	293	282	251	251	240	243	249	294
1897..	217	221	200	187	148	189	160	184	168	178	141	128	177

Wells completed in Lima (Ohio) district from 1894 to 1897.

	Number.	Dry.	Total productive.
Wells completed in 1894	2,472	384	2,088
Wells completed in 1895	4,489	564	3,925
Wells completed in 1896	4,458	550	3,908
Wells completed in 1897	2,486	384	2,102

Rigs building in the Lima (Ohio) district from 1890 to 1897, by months.

Year.	Jan.	Feb.	Mar	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890..	56	69	.....	.....	173	239	248	212	210	194	149	109	166
1891..	120	137	155	117	115	123	137	120	117	106	91	99	120
1892..	95	115	106	112	113	104	128	126	121	112	112	49	108
1893..	62	70	63	58	90	72	52	52	61	76	66	69	66
1894..	60	83	90	88	85	76	68	95	86	92	112	110	87
1895..	114	171	208	245	305	339	317	282	294	264	194	195	244
1896..	205	216	231	201	206	147	130	106	114	120	138	91	159
1897..	94	108	102	97	100	94	76	79	71	85	88	82	90

The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in the Lima (Ohio) district in 1897:

Well record in the Lima (Ohio) district in 1897.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	252	4,710	28	217	94
February	193	3,600	28	221	108
March	210	4,820	30	200	102
April.......	215	4,040	32	187	97
May	226	4,175	31	148	100
June.................	211	4,525	25	189	94
July	242	5,855	36	160	76
August...............	193	6,740	26	184	79
September	216	6,283	33	168	71
October..............	196	5,955	39	178	85
November.............	191	4,145	43	141	88
December.............	141	2,975	33	128	82
Total	2,486	*a*4,818	384	*a*177	*a*90

a Average.

PIPE-LINE RUNS IN THE LIMA-INDIANA FIELD.

The term Lima-Indiana field is used to include all of the petroleum produced in the Lima, Ohio, and the Indiana field, which embraces all of the Trenton limestone production. In the following table of pipe-line runs it is not possible to separate the petroleum carried out of Ohio from that carried out of Indiana, and therefore the runs and shipments from these States are combined. As has been before mentioned in this report, pipe-line runs are not production. This is especially true of the Lima-Indiana field. The production by States is quite accurately given under that head.

Pipe-line runs, Lima-Indiana field, from 1887 to 1897.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	164,474	207,026	303,084	352,798	449,062
1888	359,860	428,008	534,588	587,043	705,045
1889	973,980	800,828	830,559	845,377	932,067
1890	683,750	622,799	676,175	842,416	887,590
1891	1,241,154	1,147,947	1,255,611	1,202,583	1,191,147
1892	971,607	1,008,069	1,083,801	1,042,087	1,064,478
1893	1,049,778	974,944	1,163,641	1,074,290	1,187,939
1894	1,265,267	1,106,493	1,353,591	1,295,619	1,424,182
1895	1,213,841	1,029,385	1,291,355	1,405,424	1,540,972
1896	1,739,291	1,631,939	1,795,745	1,859,882	1,945,979
1897	1,547,658	1,589,905	1,733,521	1,647,997	1,685,011

Year.	June.	July.	August.	September.	October.
1887	474,535	389,997	490,162	465,743	444,941
1888	774,710	896,034	975,235	868,826	939,468
1889	843,844	805,744	968,449	875,201	850,077
1890	916,289	1,105,885	1,149,877	1,289,577	1,342,158
1891	1,207,884	1,236,291	1,240,841	1,252,375	1,257,986
1892	1,099,145	1,190,015	1,346,949	1,232,385	1,264,536
1893	1,245,880	1,289,991	1,390,894	1,315,933	1,302,295
1894	1,402,417	1,366,310	1,469,372	1,325,352	1,405,042
1895	1,541,221	1,713,937	1,752,150	1,778,653	1,822,002
1896	2,026,387	2,016,564	1,953,876	1,883,814	1,896,033
1897	1,689,456	1,702,339	1,668,287	1,618,488	1,649,170

Year.	November.	December.	Total.	Average.
1887	458,613	483,704	4,684,139	390,345
1888	891,999	938,188	8,899,004	741,584
1889	774,073	755,553	10,255,752	854,646
1890	1,215,960	1,186,434	11,918,910	993,243
1891	1,070,131	1,211,820	14,515,770	1,209,648
1892	1,209,953	1,244,712	13,657,737	1,138,145
1893	1,230,658	1,224,952	14,451,195	1,204,266
1894	1,334,334	1,326,371	16,074,350	1,339,529
1895	1,705,506	1,621,184	18,415,630	1,534,636
1896	1,681,715	1,778,786	22,210,011	1,850,834
1897	1,566,921	1,571,761	19,670,514	1,639,210

SHIPMENTS OF PETROLEUM FROM THE LIMA-INDIANA FIELD.

In the following table will be found the shipments in the Lima-Indiana oil field from 1887 to 1897, inclusive, by years and months. The shipments and runs correspond very closely throughout the year. The stocks only increased 365,871 barrels in 1897.

Shipments of crude petroleum from the Lima-Indiana field from 1887 to 1897.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Average.
1887	....	10,957	32,613	77,900	101,306	104,440	174,824	20,019	30,944	43,168	78,827	76,327	751,325	68,302
1888	81,569	207,040	243,964	210,725	159,620	179,192	227,707	401,175	301,316	370,378	287,934	382,448	3,053,068	254,422
1889	367,524	862,807	391,026	340,889	309,238	352,886	361,694	464,325	626,207	715,386	759,702	750,244	5,801,928	483,494
1890	156,085	111,604	123,125	115,223	169,662	700,422	874,121	846,360	813,817	723,725	657,614	907,548	6,199,306	516,609
1891	968,887	837,928	330,448	336,854	1,078,489	923,605	997,681	1,166,054	1,260,598	1,408,343	1,391,400	1,454,578	12,154,865	1,012,905
1892	1,355,362	1,346,541	1,532,606	1,512,358	1,427,753	1,492,543	1,389,501	1,342,949	1,125,335	1,315,994	1,323,204	1,340,734	16,504,880	1,375,407
1893	1,306,612	1,270,595	1,390,646	1,205,748	1,321,782	1,235,843	1,152,374	1,040,860	1,038,819	1,196,018	1,262,130	1,230,216	14,651,643	1,220,970
1894	1,199,752	1,109,110	1,247,295	1,210,391	1,150,298	1,303,957	1,023,316	1,238,183	1,023,232	1,198,801	1,285,861	1,463,566	14,453,762	1,204,480
1895	1,473,730	1,289,686	1,409,761	1,206,172	1,212,061	1,279,618	1,302,596	1,298,502	1,452,640	1,507,992	1,587,449	1,810,159	16,830,366	1,402,531
1896	1,802,361	1,593,328	1,618,117	1,546,888	1,574,627	1,667,914	1,617,519	1,745,657	1,702,721	1,704,065	1,720,720	1,727,549	20,021,466	1,668,156
1897	1,672,838	1,795,876	1,724,306	1,585,187	1,762,085	1,750,613	1,841,908	1,478,129	1,655,593	1,591,449	1,353,321	1,881,121	20,092,426	1,674,369

STOCKS OF CRUDE PETROLEUM IN THE LIMA-INDIANA FIELD.

In the following table will be found the statement of stocks of crude petroleum in the Lima-Indiana field at the close of each month from 1887 to 1897. They show a slight increase during the year 1897, of 365,871 barrels. At the end of the year the total net stocks were 22,939,639 barrels.

The stocks at the close of the year in the Appalachian field were 11,010,044 barrels, making a total of 33,949,683 barrels of crude oil in tanks, 32½ per cent being in the Appalachian field and 67½ per cent being in the Lima, Ohio, field. The increase in stocks of the Lima-Indiana field was 365,871 barrels, as above mentioned, and that of the Appalachian field 1,264,322 barrels, making an increase in stocks in both fields of 1,630,193 barrels in 1897.

Total stocks of crude petroleum in the Lima-Indiana field, at the close of each month, from 1887 to 1897.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	....	847, 817	1, 118, 288	1, 393, 186	1, 740, 942
1888	4, 367, 355	4, 588, 323	4, 949, 446	5, 367, 401	5, 980, 283
1889	10, 415, 880	10, 852, 202	11, 288, 793	11, 792, 707	12, 413, 137
1890	14, 104, 018	14, 180, 090	14, 241, 340	14, 153, 259	14, 298, 966
1891	21, 233, 645	21, 537, 789	21, 957, 948	22, 319, 191	22, 424, 364
1892	21, 692, 318	21, 350, 912	20, 896, 185	20, 425, 914	20, 062, 639
1893	18, 355, 492	18, 059, 846	17, 877, 265	17, 747, 249	17, 616, 527
1894	18, 565, 823	18, 566, 158	18, 675, 275	18, 763, 242	19, 041, 624
1895	19, 898, 378	19, 642, 870	19, 524, 463	19, 723, 715	20, 052, 627
1896	21, 431, 778	21, 473, 447	21, 651, 075	21, 964, 069	22, 335, 420
1897	23, 174, 324	22, 968, 353	22, 977, 567	23, 040, 378	22, 963, 304

Year.	June.	July.	August.	September.
1887	2, 111, 037	2, 326, 211	2, 632, 828	2, 957, 900
1888	6, 593, 165	7, 282, 088	7, 852, 705	8, 392, 493
1889	12, 902, 628	13, 344, 795	13, 846, 765	14, 092, 706
1890	14, 513, 553	14, 744, 004	19, 086, 736	19, 843, 950
1891	22, 704, 034	22, 930, 048	22, 993, 496	22, 975, 470
1892	19, 668, 894	19, 467. 900	19, 505, 399	19, 150, 058
1893	17, 642, 117	17, 779, 733	18, 129, 767	18, 408, 814
1894	19, 142, 598	19, 504, 651	19, 736, 628	20, 040, 748
1895	20, 314, 230	20, 725, 571	21, 179, 219	21, 351, 757
1896	22, 693, 894	23, 094, 851	23, 304. 312	23, 091, 525
1897	22, 902, 147	22, 762, 578	22, 952, 736	22, 840, 818

Total stocks of crude petroleum in the Lima-Indiana field, at the close of each month, from 1887 to 1897—Continued.

[Barrels of 42 gallons.]

Year.	October.	November.	December.	Average.
1887	3,359,674	3,739,459	4,148,469	2,397,801
1888	8,920,086	9,499.482	9,810,714	6,966,962
1889	14,224,747	14,554,662	14,105,149	12,819,514
1890	20,442,065	20,967,258	20,971,395	16,795,553
1891	22,722,465	22,375,030	22,103,705	22,456,438
1892	18,800,715	18,687,464	18,604,442	19,859,403
1893	18,527,901	18,499,669	18,497,340	18,095.143
1894	20,246,989	20,295.461	20,158,266	19,394.788
1895	21,565,766	21,683,823	21,494,848	20,596,439
1896	23,290.538	23,251,533	23,302,770	22,573,768
1897	22,858,539	23,072,139	22.762,779	22,939,639

PRICES OF CRUDE PETROLEUM IN THE LIMA-INDIANA FIELD.

In the following table are given the average monthly prices of Lima (Ohio) and Indiana crude petroleum, per barrel of 42 gallons each, in the year 1897:

Average monthly prices of Ohio and Indiana crude petroleum, per barrel of 42 gallons, in 1897.

Month.	North Lima.	South Lima.	Indiana.
	Cents.	*Cents.*	*Cents.*
January	58½	53½	53½
February	56	51	51
March	56¼	51¼	51¼
April	52⅞	47⅞	47⅞
May	51⅙	46⅙	46⅙
June	50	45	45
July	48½	43½	43½
August	47	42	42
September	47	42	42
October	46½	41½	41½
November	46	41	41
December	46	41	41
Average	50½	45½	45½
Average of North and South Lima	48		....

In the following table are given the fluctuations in prices for the various grades of Lima oil in 1897. The dates are those on which changes in prices were made.

Fluctuation in prices of Lima (Ohio) and Indiana crude petroleum in 1897.

Date.	North Lima.	South Lima.	Indiana.
January 1	60	55	55
January 18	58	53	53
January 23	56	51	51
March 24	57	52	52
April 3	56	51	51
April 5	55	50	50
April 9	52	47	47
April 28	51	46	46
April 30	50	45	45
May 5	51	46	46
May 18	52	47	47
May 28	50	45	45
June 29	49	44	44
July 19	48	43	43
August 3	47	42	42
October 18	46	41	41

EASTERN OR SOUTHEASTERN OHIO DISTRICT.

The production of this district includes all of that part of the Appalachian oil field in Ohio, the principal subdivisions of which are known as the Macksburg, Corning, Steubenville, Marietta, Sistersville, Newcastle, and Barnesville.

The production of the Southeastern Ohio district for the last twelve years is given in the following table:

Production of petroleum in the Southeastern Ohio district from 1885 to 1897.

Year.	Barrels.	Year.	Barrels.
1885	661,580	1892	1,190,302
1886	703,945	1893	2,601,394
1887	372,257	1894	3,183,370
1888	297,774	1895	3,693.248
1889	317,037	1896	3,365,365
1890	1,108,334	1897	2,877,193
1891	422,883		

It will be noticed in the above table that there has been a decrease of 488,172 barrels in 1897 as compared with 1896, and that the highest production was in 1895.

In the years prior to 1891 most of the oil was produced in the old Macksburg field.

The following table shows the total production of crude petroleum in southeastern Ohio, by months, beginning with the year 1888 and ending 1897:

Total production of crude petroleum in the Southeastern Ohio district from 1888 to 1897, by months.

[Barrels.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1888..	20,144	25,327	23,515	23,720	25,837	24,426	31,535	23,537	22,945	25,442	25,831	25,515	297,774
1889..	24,855	23,218	26,382	24,708	24,961	24,011	22,619	24,752	22,807	28,384	32,867	37,473	317,037
1890..	36,713	40,712	53,193	60,729	80,167	98,268	118,182	132,173	140,634	138,224	113,664	95,675	1,108,334
1891..	89,061	40,620	28,297	29,361	28,935	25,014	30,571	28,828	31,591	27,536	28,428	34,641	422,883
1892..	33,762	32,894	42,371	45,439	50,407	55,930	69,678	111,377	151,543	206,005	188,391	202,505	1,190,302
1893..	189,874	209,948	238,133	217,001	204,151	206,106	213,431	221,865	220,589	242,353	222,428	215,515	2,601,394
1894..	209,225	213,721	253,979	268,736	283,371	273,876	267,144	275,360	278,704	303,441	278,162	277,651	3,183,370
1895..	251,865	223,140	276,422	285,314	285,436	290,763	305,222	337,206	377,785	383,489	345,402	331,204	3,693,248
1896..	321,895	281,776	293,538	291,358	286,669	278,634	274,317	270,135	255,326	270,752	251,367	289,598	3,365,365
1897..	293,801	262,035	266,343	255,213	266,760	259,100	245,876	227,013	217,018	203,127	183,683	197,224	2,877,193

PIPE-LINE RUNS IN THE SOUTHEASTERN OHIO DISTRICT.

In the following tables the pipe-line runs and the shipments from the Macksburg or Southeastern Ohio district are given from 1885 to 1897:

Pipe-line runs in the Southeastern Ohio district from 1885 to 1897.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Average.
1885..	11, 894	20, 626	27, 066	40, 527	58, 258	64, 982	75, 737	74, 228	68, 110	63, 619	60, 926	61, 113	627, 086	52, 257
1886..	54, 806	46, 694	58, 795	64, 137	58, 596	65, 379	56, 966	57, 492	48, 918	46, 937	41, 359	40, 578	640, 657	53, 388
1887..	37, 134	28, 514	33, 995	29, 796	30, 601	29, 586	22, 413	26, 659	22, 903	20, 458	19, 902	17, 079	319, 040	26, 587
1888..	16, 257	18, 861	17, 283	21, 187	21, 349	21, 511	21, 785	18, 558	22, 058	18, 809	20, 802	20, 950	239, 410	19, 951
1889..	18, 174	16, 239	19, 676	20, 144	20, 283	18, 536	16, 705	16, 607	16, 875	21, 555	25, 415	28, 567	238, 776	19, 898
1890..	29, 872	34, 022	45, 362	53, 905	72, 158	90, 827	111, 584	121, 349	138, 310	129, 717	106, 552	87, 955	1, 021, 613	85, 134
1891..	86, 058	45, 618	23, 055	25, 070	24, 263	21, 689	24, 858	24, 432	27, 006	23, 428	23, 073	28, 682	377, 232	31, 436
1892..	24, 801	27, 620	39, 010	40, 424	43, 569	50, 007	64, 107	106, 082	135, 353	212, 470	176, 852	196, 852	1, 117, 147	93, 096
1893..	183, 781	211, 658	235, 177	211, 102	199, 929	146, 626	148, 622	152, 912	156, 124	149, 773	134, 923	144, 488	2, 075, 115	172, 926
1894..	138, 172	121, 627	150, 095	190, 677	239, 912	228, 267	221, 999	249, 472	202, 364	220, 557	199, 787	199, 774	2, 362, 703	196, 892
1895..	94, 999	181, 155	220, 883	229, 159	225, 816	227, 643	251, 003	279, 602	310, 400	322, 439	286, 932	324, 447	2, 954, 478	246, 207
1896..	321, 468	272, 933	296, 565	294, 603	279, 317	283, 385	267, 797	270, 280	252, 351	267, 337	253, 909	278, 231	3, 338, 176	278, 181
1897..	289, 720	263, 896	284, 298	255, 715	266, 687	257, 925	242, 160	232, 208	214, 283	202, 847	190, 028	194, 168	2, 893, 935	241, 161

It will be noticed that the pipe-line runs are for this year greater than the production. The other years, however, have been accumulating a much larger percentage and have gained a large amount over the runs.

SHIPMENTS OF PETROLEUM FROM THE SOUTHEASTERN OHIO DISTRICT.

Shipments of crude petroleum and refined petroleum reduced to crude equivalent from the Southeastern Ohio district from 1886 to 1897.

[Barrels of 42 gallons.]

Year.	January.	February.	March	April.	May.	June.	July.
1886..	60,119	42,525	32,277	23,578	28,986	40,211	28,832
1887..	52,065	23,908	17,593	16,558	16,002	17,384	16,504
1888..	40,076	30,045	4,122	14,920	15,275	15,630	9,083
1889..	11,847	16,168	23,939	8,611	9,027	8,934	15,269
1890..	44,306	38,898	35,041	30,975	13,070	22,851	46,394
1891..	54,363	27,160	1,040	2,094	1,060	41,725	820
1892..	2,594	2,200	1,763	1,600	252	37,989	1,834
1893..	7,174	6,556	8,218	5,906	2,338	1,123	1,025
1894..	3,366	3,932	2,874	2,272	1,998	959	2,569
1895..	4,370	3,106	3,154	1,130	869	1,756	583
1896..	4,128	3,116	1,874	1,309	1,026	300	0
1897..	2,948	2,437	2,063	2,776	400	1,645	0

Year.	August.	September	October.	November.	December.	Total.	Average.
1886..	45,882	47,992	53,156	51,608	49,260	504,426	42,036
1887..	27,719	35,030	37,978	34,508	39,654	334,903	27,909
1888..	6,989	32,698	47,572	47,066	26,940	290,416	24,201
1889..	14,507	22,669	50,447	47,924	47,090	276,432	23,036
1890..	107,175	73,469	50,780	54,540	53,704	578,203	48,184
1891..	2,318	3,283	3,040	2,700	2,236	141,839	11,820
1892..	1,555	2,102	3,773	4,358	6,413	66,463	5,539
1893..	586	1,964	2,524	4,538	2,563	44,515	3,710
1894..	2,309	3,839	4,377	4,264	3,999	36,758	3,063
1895..	1,874	2,124	4,177	6,716	3,332	33,191	2,766
1896..	235	599	3,641	2,560	2,561	21,349	1,779
1897..	1,416	2,323	3,496	3,510	55	23,069	1,922

This table embraces the crude oil delivered to refineries in Parkersburg and Marietta. The balance of the shipments are included in the trunk-line statements.

STOCKS OF CRUDE PETROLEUM IN THE SOUTHEASTERN OHIO DISTRICT.

Total stocks of crude petroleum in the Southeastern Ohio district at the close of each month from 1886 to 1897, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1886..	324, 483	332, 322	362, 923	407, 212	440, 329	467, 599	468, 796
1887..	404, 315	408, 926	425, 325	438, 562	453, 162	465, 363	472, 273
1888..	380, 551	386, 293	400, 602	407, 086	413, 858	420, 631	434, 573
1889..	363, 620	357, 527	360, 121	364, 796	376, 052	397, 718	387, 089
1890..	296, 413	291, 536	301, 856	324, 786	388, 874	451, 851	517, 042
1891..	685, 120	503, 284	480, 618	480, 364	453, 809	433, 773	401, 358
1892..	461, 616	468, 861	460, 750	462, 383	475, 768	447, 685	457, 176
1893..	410, 715	418, 513	397, 127	404, 951	407, 715	421, 222	413, 935
1894..	390, 977	388, 341	379, 037	376, 883	325, 664	294, 427	271, 801
1895..	172, 461	193, 935	236, 022	242, 317	204, 030	211, 740	184, 784
1896..	246, 557	290, 225	345, 405	348, 997	324, 443	248, 799	220, 759
1897..	485, 986	507, 619	522, 985	537, 636	515, 716	523, 944	519, 334

Year.	August.	September.	October.	November.	December.	Average.
1886......	456, 621	461, 842	437, 299	427, 950	419, 248	417, 219
1887......	471, 214	459, 085	441, 563	426, 957	404, 382	439, 261
1888......	444, 006	427, 797	394, 807	365, 873	351, 128	402, 267
1889......	389, 189	383, 393	354, 498	331, 939	310, 848	364, 732
1890......	531, 215	596, 056	660, 573	703, 031	698, 129	480, 113
1891......	378, 857	388, 855	431, 450	461, 037	454, 232	462, 730
1892......	462, 306	441, 494	434, 560	432, 283	422, 142	452, 252
1893......	426, 552	443, 669	458, 692	446, 503	415, 900	422, 124
1894......	241, 439	197, 660	179, 867	152, 200	147, 318	278, 801
1895......	182, 209	169, 850	192, 060	211, 591	231, 048	202, 671
1896......	214, 159	217, 946	434, 786	469, 580	465, 953	318, 967
1897......	541, 300	516, 498	496, 550	456, 413	436, 844	505, 069

WELL RECORDS OF THE SOUTHEASTERN OR SOUTHERN OHIO DISTRICT.

The general conditions of this part of the Appalachian field in Ohio were discussed in a former part of this report. In the following tables will be found statistics of the wells completed, number of dry holes drilled, number of wells drilling, and number of rigs building. This does not include all of the wells drilled in southeastern Ohio, for a very large part are included under the head of the Southwestern district:

Total number of wells completed in the Southeastern Ohio district in 1897.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	20	14	0	11	10	55
February	6	14	1	2	7	30
March	8	25	4	6	3	46
April	18	20	3	9	8	58
May	14	26	4	6	13	63
June	6	16	15	9	5	51
July	6	12	11	4	2	35
August	3	16	15	5	5	44
September	0	12	11	10	1	34
October	2	8	9	3	7	29
November	1	10	5	4	2	22
December	3	15	5	1	7	31
Total	87	188	83	70	70	498

Initial daily production of wells completed in the Southeastern Ohio district in 1897.

[Barrels.]

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	127	79	0	270	23	499
February	35	190	25	5	47	302
March	36	246	18	105	28	433
April	75	119	22	85	60	361
May	68	135	10	102	59	374
June	19	120	75	33	40	287
July	38	49	56	5	10	158
August	40	46	94	50	235	465
September	0	69	56	115	0	240
October	20	20	47	40	43	170
November	0	41	81	70	0	192
December	22	38	18	10	94	182
Average	40	96	42	74	53	305

Total number of dry holes drilled in the Southeastern Ohio district in 1897.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	4	6	0	4	6	20
February	1	6	0	1	2	10
March	1	6	1	3	0	11
April	4	8	1	5	2	20
May	2	12	2	3	7	26
June	2	8	6	7	2	25
July	2	4	4	3	1	14
August	0	11	5	4	2	22
September	0	6	3	4	1	14
October	0	4	3	1	1	9
November	1	6	1	2	2	12
December	1	9	2	0	1	13
Total	18	86	28	37	27	196

Total number of wells drilling in the Southeastern Ohio district in 1897.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	2	10	0	2	5	19
February	4	12	3	4	4	27
March	9	10	1	4	7	31
April	4	10	0	0	8	22
May	0	7	3	2	9	21
June	4	13	7	1	1	26
July	0	9	6	1	6	22
August	0	10	8	2	5	25
September	1	7	6	2	2	18
October	0	9	1	1	4	15
November	1	12	3	1	4	21
December	0	7	4	2	2	15
Average	2	10	3	2	5	22

Total number of rigs building in the Southeastern Ohio district in 1897.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	3	16	0	3	3	25
February	8	12	2	0	1	23
March	5	10	2	1	6	24
April	4	14	4	1	2	25
May	3	10	3	2	3	21
June	2	8	3	1	2	16
July	3	9	5	0	1	18
August	3	9	2	1	0	15
September	4	3	2	0	2	11
October	3	10	3	1	2	19
November	3	12	1	2	1	19
December	2	3	2	2	1	10
Average	4	10	2	1	2	19

In the following tables are given the well records in the Southeastern Ohio district from 1891 to 1897:

Number of wells completed in the Southeastern Ohio district from 1891 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	.....	.....	.....	.....	.....	.....	.....	.....	.....	9	10	8	27
1892	7	9	12	7	4	8	5	2	4	2	14	2	76
1893	10	15	13	19	24	15	26	18	21	15	7	7	190
1894	9	6	15	17	17	21	23	18	19	21	22	27	215
1895	25	17	31	37	57	56	50	48	40	41	25	33	460
1896	43	41	43	45	71	49	66	51	50	43	60	57	619
1897	55	30	46	58	63	51	35	44	34	29	22	31	498

Initial daily production of new wells in the Southeastern Ohio district from 1891 to 1897, by months.

[Barrels.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891	.....	.....	.....	.....	.....	.....	.....	.....	.....	36	265	70	124
1892	60	152	393	65	291	25	43	2	0	20	117	0	97
1893	209	168	109	254	350	210	323	398	240	234	37	78	218
1894	143	50	74	172	246	223	262	232	180	468	215	433	225
1895	387	348	680	506	748	465	528	406	398	269	284	317	445
1896	338	359	787	413	554	426	473	300	434	594	592	498	481
1897	499	302	433	361	374	287	158	465	240	170	192	182	305

Total number of dry holes drilled in the Southeastern Ohio district from 1891 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	5	4	14
1892..	2	3	4	4	4	5	1	0	4	1	4	2	34
1893..	0	2	4	3	8	2	7	3	7	4	4	2	46
1894..	3	2	8	7	5	9	8	8	7	8	11	9	85
1895..	11	3	6	9	9	18	11	14	7	20	5	12	125
1896..	11	15	9	16	31	11	23	19	12	13	24	16	200
1897..	20	10	11	20	26	25	14	22	14	9	12	13	196

Number of wells drilling in the Southeastern Ohio district at the close of each month from 1891 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	14	10	13
1892..	15	15	12	9	14	9	6	6	6	10	7	9	10
1893..	14	10	15	15	13	15	13	19	12	8	9	12	13
1894..	11	4	19	5	17	15	18	18	16	15	19	22	15
1895..	19	21	16	34	32	38	35	41	35	27	33	33	30
1896..	33	22	38	42	27	36	35	26	33	35	40	36	34
1897..	19	27	31	22	21	26	22	25	18	15	21	15	22

Rigs building in the Southeastern Ohio district from 1891 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	20	4	15
1892..	18	17	14	13	21	10	8	11	13	16	13	13	14
1893..	16	17	23	11	4	9	12	9	13	9	13	13	12
1894..	9	13	13	9	13	13	18	18	15	27	19	17	15
1895..	16	23	21	26	24	28	25	30	24	24	38	31	26
1896..	38	24	24	30	22	21	23	26	22	30	22	22	25
1897..	25	23	24	25	21	16	18	15	11	19	19	10	19

The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in the Macksburg district or the Southeastern Ohio oil field in 1897:

Well record in the Macksburg (Ohio) district in 1897.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	55	499	20	19	25
February	30	302	10	27	23
March	46	433	11	31	24
April	58	361	20	22	25
May	63	374	26	21	21
June	51	287	25	26	16
July	35	158	14	22	18
August	44	465	22	25	15
September	34	240	14	18	11
October	29	170	9	15	19
November	22	192	12	21	19
December	31	182	13	15	10
Total	498	*a* 305	196	*a* 22	*a* 19

a Average.

THE MECCA-BELDEN DISTRICT.

PRODUCTION.

The following table gives the production of crude petroleum in the Mecca-Belden district in 1897:

Production of crude petroleum in the Mecca-Belden district in 1897.

District.	Barrels of 42 gallons.	Value.	Price per barrel.
Belden, Lorain County	500	$1,972	$3.94
Mecca, Trumbull County	145	1,148	7.91½
Total	645	3,120	4.84

These fields which yield the finest natural lubricating oil continue to produce nearly the same amount annually. They are isolated by many miles from any other oil fields and are themselves widely separated. The Mecca district is in northern Trumbull County, not far from Warren, Ohio, and the Belden is in Lorain County, just south of Elyria.

Contrary to other production, the price advanced from an average of $4.35 a barrel in 1896 to $4.84 a barrel in 1897.

In both cases the oil comes from the Berea sandstone.

In the following tables are given the production and value and stocks of the crude petroleum in this district from 1892 to 1897:

Production and value of crude petroleum in the Mecca-Belden district of Ohio from 1892 to 1897.

Year.	Belden district, Lorain County.			Mecca district, Trumbull County.			Total.		
	Production.	Value.	Value per barrel.	Production.	Value.	Value per barrel.	Production.	Value.	Value per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
1892....	1,732	$9,280	$5.36	1,380	$11,821	$8.57	3,112	$21,101	$6.78
1893....	1,120	8,014	7.15	451	3,321	7.36	1,571	11,335	7.21½
1894....	740	3,276	4.43	200	1,200	6.00	940	4,476	4.76
1895....	833	4,200	5.04	543	4,029	7.42	1,376	8,229	5.98
1896....	520	1,848	3.55	146	1,049	7.18	666	2,897	4.35
1897....	500	1,972	3.94	145	1,148	7.91½	645	3,120	4.84

STOCKS OF PETROLEUM IN THE MECCA-BELDEN DISTRICT, OHIO.

Stocks at wells in the Mecca-Belden district of Ohio.

Year ending Dec. 31—	Barrels.	Year ending Dec. 31—	Barrels.
1891........................	4,048	1895........................	390
1892........................	161	1896........................	70
1893........................	403	1897........................	69
1894........................	225		

INDIANA.

The oil-producing territory of this State is similar to that of Ohio and is probably connected with it. It extends in a general direction a little north of east, along the contour of one of the most prominent extensions of the Cincinnati arch. Outside of a few wells at Terre Haute, all of the oil in this State comes from the Trenton limestone. The productive zone or belt is, in a general way, 40 miles long and from 8 to 12 miles in width, and includes parts of Adams, Jay, Blackford, Wells, Grant, Huntington, and Wabash counties. There were several small pools opened up during the year, namely, at Peru, in Miami County, and Alexander, in Madison County.

The Trenton limestone has a vast number of rolls and dimples on its buried surface, together with subordinate anticlines and synclines, many of them prominent enough to separate the gas, oil, and salt water. These irregularities of the buried surface of this limestone can only be determined by the drill, as the original strata are usually covered for many feet by northern drift. Therefore the irregularities in the surface of the limestone must be determined by a close comparison of the levels of the different wells.

The oil and gas are found usually near the surface of the limestone, in some instances 40 to 50 feet in the rock, but generally a greater distance develops a flow of salt water. The whole thickness of the Trenton limestone formation, as determined by a number of wells that have been drilled through it, is about 460 to 560 feet.

Mr. W. S. Blatchley, State geologist of Indiana, in his twenty-second annual report, for 1897, enumerates the advantages of operating in the Indiana fields, as follows:

> (*a*) The wells are comparatively shallow, the Trenton limestone in most instances being struck at less than 1,000 feet; (*b*) it is seldom that more than 150 feet of drive pipe and 400 feet of casing are necessary; (*c*) on account of a comparatively level surface, a large number of wells can be connected to and pumped with one source of power; (*d*) gas for fuel or for running gas engines is usually plentiful; (*e*) transportation facilities are excellent, a system of pipe lines permeating all parts of the main field.

Mr. Blatchley further says:

> But few extensions of any importance were made in the main Indiana oil field in 1897. The prevailing low price of petroleum prevented operations in territory which had been fairly well tested.
>
> The "wildcatters" direct most of their attention to the pools at Alexander and Peru. They hoped to strike something better than the main field promised. Moreover, all of the most promising prospective territory within or near the lines shown on last season's map was under lease, and the operators aimed only to protect property lines, leaving active drilling for the future, when the price of the product shall have increased.
>
> In Jay County some wells were drilled in the north half of section 7, the northeast quarter of section 8, and the north half of section 18 (24 north, 13 east), in territory which had not before been tested.
>
> The Diamond Oil Company has had remarkable success with its lease on the A. H. Myers farm, in section 30 (24 north, 12 east), Harrison Township, Blackford County. Of three wells put down in 1896 and nine in 1897, all have been good producers, starting out from 60 to 300 barrels a day. The total production for the year was 75,000 barrels on the 184 acres, proving it to be one of the best leases in the main field. The Trenton is found at depths varying from 934 to 972 feet. Numerous bores have been put down on all sides of this lease, but they have for the most part proved dry holes or small producers.
>
> No developments of importance were made in Adams County.
>
> In Wells County several good wells were located on the W. Pouless farm, in section 6, Jackson Township, which before had been undrilled. It is estimated by a conservative operator that the old wells of the county have had an average decline of 40 per cent in output within the year.
>
> In Grant County the only new developments have been in the north half of sections 2 and 3, Van Buren Township, where some fair wells were completed by the Ziegler Oil Company.
>
> In Huntington County a number of good wells were completed in the southwest corner of Jefferson Township, but the lines of the productive area were unchanged. Sections 37 and 34, inclusive, in Salamonie Township, will doubtless be found to be paying territory in the future, though one or two test bores have developed only salt water.

The Alexander pool.—On April 23, 1897, a well near Alexander, Madison County, struck the Trenton limestone at 890 feet, and drilling into it 100 feet, passed two oil pays. The well was shot and it started off at the rate of 250 barrels a day. This well was located on the N. Carver farm, 2 miles northeast of Alexander. A number of wells followed in quick succession, and many of them were large "gassers" as well as oil producers.

The following are the statistics of the Alexander field, as taken from Mr. Blatchley's report for 1897:

Statistics of the Alexander oil field in 1897.

Wells drilled for oil in Madison County in 1897		67
Wells that have produced oil in commercial quantities		29
Wells that have produced gas in commercial quantities		35
Dry holes		3
Wells producing oil January 1, 1898		21
Wells allowing escape of gas January 1, 1898		17
Estimated amount of gas wasted daily January 1, 1898	cubic feet	20,000,000
Daily production of oil January 1, 1898	barrels	400
Average daily production per well January 1, 1898	do	18

The large waste of gas caused action to be taken by Mr. Leach, State gas inspector, with a view to stop the production until the gas was utilized. The oil produced in this field up to January 1, 1898, was 71,767 barrels.

The Peru pool.—This was the most important development in Indiana during 1897. After a number of dry holes and salt water holes had been drilled near this locality a well was completed on the lot of W. N. Dukes, in the northwestern part of Peru on July 19, 1897, which found oil a few feet in the Trenton, and filled up and flowed a small stream through the casing, amounting to 10 or 12 barrels per day. The top of the Trenton was found at 855 feet, or 198 feet below sea level. When tubed and pumped it gave 120 barrels a day. There were several other good producers, and by September 30 rigs were up and drilling about the original wells. Near the original well, drilled in 1897, a well showed the following record: Drift, 20 feet; Niagara limestone, 375 feet; Hudson River shale, 255 feet; Utica shale, 248 feet; top of Trenton at 898 feet; total depth, 933 feet.

The first paying oil was found near the top of the limestone, and in a number of instances a second pay was developed 25 feet from the top of the limestone. Owing to the porous nature of the strata and the closeness of the first pay to the Utica shale, very few of the wells were shot.

There is little or no gas in this field, and pumping has to be resorted to. The salt water lies close to the pays and is ready at any time to take the place of the oil. The oil is dark and gummy, and so heavy that it carries considerable water, and therefore requires thorough steaming to separate it and put it in condition to be received by the pipe line.

The statistics of this field are taken from the report of Mr. Blatchley for 1897:

Well records in the Peru pool, Indiana, in 1897.

Wells drilled in 1897		229
Producing wells January 1, 1898		178
Abandoned wells after producing		25
Wells, dry holes		26
Daily production January 1, 1898	barrels	2,264
Average daily production per well January 1, 1898	do	12.7

Production of petroleum in the Peru pool, Indiana, in 1897, by months.

	Barrels.
September	10,257
October	55,376
November	88,725
December	67,918
Total	222,276

The Broad Ripple oil field.—This field is located only 5 miles northwest of Indianapolis and produced a considerable amount of gas in past years. In August, 1897, oil was found in a well drilled on the H. M. Hessong farm by the White River Company. After this well was shot it pumped 125 barrels a day for a week, but by January 1 its production was down to 15 barrels a day. The depth of the wells in this field range from 925 to 950 feet, and the top of the Trenton is at about 120 feet above tide. The following statistics are taken from Mr. Blatchley's report for 1897:

Well records in the Broad Ripple oil field to January 1, 1898.

Wells drilled in 1897		29
Wells producing oil in commercial quantities		12
Wells producing gas in commercial quantities		4
Dry holes		13
Wells drilling		4
Total daily production January 1, 1898	barrels	230
Average daily production per well January 1, 1898	do	19

Production of the Broad Ripple oil field by months in 1897.

	Barrels.
August	188
September	1,886
October	1,070
November	1,660
December	2,892
Total	7,696

Notwithstanding the new pools developed in the State in 1897, there was a falling off of 558,376 barrels, or of 11.93 per cent as compared with 1896. The price declined from an average of 63 cents in 1896 to 45.6 cents a barrel in 1897, a loss of 17.4 cents, or about 27½ per cent, so that the production did not show as great a decline as the price. The number of wells completed in 1896 was 1,180 as compared with 686 in 1897, the latter number being only 58 per cent of the former. The average initial daily production in 1897 was 25 barrels to a well as compared to 35 barrels in 1896, when the dry holes are deducted. A very large proportion of the wells drilled in 1897 were in Wells and Miami counties.

PRODUCTION.

In the following table will be found a statement of the production of petroleum in Indiana from 1890 to 1897:

Production of petroleum in Indiana from 1890 to 1897.

	1890.	1891.	1892.	1893.
Total production (barrels of 42 gallons)	63,496	136,634	698,068	2,335,293
Total value at wells of all oils produced, excluding pipage	$32,462	$54,787	$260,620	$1,050,882
Value per barrel........	$0.51⅛	$0.40	$0.37	$0.45

	1894.	1895.	1896.	1897.
Total production (barrels of 42 gallons)	3,688,666	4,386,132	4,680,732	4,122,356
Total value at wells of all oils produced, excluding pipage	$1,774,260	$2,811,444	$2,954,411	$1,880,412
Value per barrel........	$0.48	$0.64	$0.63	$0.456

The following table shows the monthly production of the Indiana field from 1891 to 1897, inclusive. The first oil produced in this State from the Trenton limestone came from a well drilled at Montpelier, Blackford County in 1889. In this same year oil was first discovered at Terre Haute:

Total production of petroleum in Indiana from 1891 to 1897, by months.

[Barrels.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Jan	6,171	15,841	111,824	259,000	300,568	365,582	315,980
Feb	5,981	18,946	96,025	232,107	230,559	341,743	309,867
Mar....	5,159	24,794	134,549	282,376	310,303	386,586	347,922
Apr	4,973	26,184	146,493	287,330	352,077	395,032	327,744
May ...	5,757	31,033	186,939	321,502	397,001	417,963	346,515
June...	8,136	40,888	209,616	333,479	403,569	434,167	347,884
July ...	10,809	49,203	221,666	327,349	434,376	422,968	351,280
Aug....	11,603	56,109	248,353	345,031	420,132	407,238	345,856
Sept ...	16,500	66,034	245,615	319,588	409,169	415,675	329,379
Oct	19,029	95,699	252,568	339,424	393,153	394,283	372,113
Nov....	20,801	129,270	245,607	304,030	373,789	337,331	379,896
Dec	21,715	144,067	236,038	337,450	361,436	362,164	347,920
Total.	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,122,356

WELL RECORDS IN THE INDIANA FIELD.

The following tables show the total number of wells completed, the initial daily production of the producing wells, the total number of dry holes, and the total number of wells drilling and rigs building in the Indiana oil field for each month during 1897:

Total number of wells completed in Indiana in 1897, by counties.

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Madison.	Miami.	Marion.	Delaware.	Wabash.	Total.
January	3	8	4	5	6	15	0	0	0	0	0	41
February	5	5	5	2	5	13	0	0	0	0	0	35
March	3	6	4	7	5	15	0	0	0	0	0	40
April	5	6	5	6	4	21	0	0	0	0	0	47
May	5	6	3	4	0	26	5	0	0	0	0	49
June	4	7	7	1	6	16	11	0	0	0	0	52
July	5	8	6	0	5	24	12	0	0	0	0	60
August	3	5	3	2	4	17	11	0	0	0	0	45
September	4	8	3	0	7	12	13	7	1	0	0	55
October	1	4	1	1	4	12	7	55	3	1	0	89
November	2	7	2	2	4	5	3	88	5	1	0	119
December	2	2	1	0	2	5	4	28	7	2	1	54
Total	42	72	44	30	52	181	66	178	16	4	1	686

Initial daily production of wells completed in Indiana in 1897, by counties.

[Barrels.]

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Madison.	Miami.	Marion.	Delaware.	Wabash.	Total.
January	30	145	90	140	90	235	0	0	0	0	0	730
February	60	245	100	120	55	420	0	0	0	0	0	1,000
March	115	110	135	275	15	350	0	0	0	0	0	1,000
April	95	205	140	85	15	260	0	0	0	0	0	800
May	160	240	55	180	0	595	65	0	0	0	0	1,295
June	105	80	225	25	95	210	160	0	0	0	0	900
July	140	220	205	0	100	520	615	0	0	0	0	1,800
August	45	40	55	70	105	345	190	0	0	0	0	850
September	70	140	90	0	45	350	235	1,030	50	0	0	2,010
October	20	20	15	10	120	135	155	3,540	135	50	0	4,200
November	55	75	95	35	65	60	20	3,285	100	0	0	3,790
December	0	80	20	0	40	110	115	330	185	150	15	1,045
Average	75	133	102	78	62	300	129	682	39	17	1	1,618

Total number of dry holes drilled in Indiana in 1897, by counties.

Month.	Adams.	Black-ford.	Grant.	Hunt-ington.	Jay.	Wells.	Mad-ison.	Mi-ami.	Ma-rion.	Dela-ware.	Total.
January	1	1	0	0	1	5	0	0	0	0	8
February	2	1	1	0	2	3	0	0	0	0	9
March	1	1	0	1	4	0	0	0	0	0	7
April	1	4	0	0	3	4	0	0	0	0	12
May	1	1	0	0	0	0	3	0	0	0	5
June	1	2	0	0	3	2	8	0	0	0	16
July	0	4	0	0	0	2	5	0	0	0	11
August	2	2	0	0	1	1	3	0	0	0	9
September	2	2	0	0	4	1	7	0	0	0	16
October	0	2	0	0	0	2	4	3	0	0	11
November	0	3	0	0	1	0	2	9	2	1	18
December	2	0	0	0	0	0	2	0	3	1	8
Total	13	23	1	1	19	20	34	12	5	2	130

Total number of wells drilling in Indiana in 1897, by counties.

Month.	Adams.	Black-ford.	Grant.	Hunt-ington.	Jay.	Wells.	Mad-ison.	Mi-ami.	Ma-rion.	Dela-ware.	Total.
January	2	4	5	4	5	18	0	0	0	0	38
February	2	3	5	6	4	15	0	0	0	0	35
March	1	5	2	4	1	17	0	0	0	0	30
April	2	3	9	8	0	11	0	0	0	0	33
May	3	4	3	4	3	10	8	0	0	0	35
June	4	6	2	0	3	18	6	0	0	0	39
July	3	4	4	2	4	12	5	0	0	0	34
August	3	4	3	0	2	13	4	0	0	0	29
September	2	5	1	0	3	8	6	20	3	0	48
October	2	3	1	1	3	7	2	17	3	1	40
November	2	4	0	0	2	6	4	22	4	1	45
December	2	5	1	1	3	5	0	9	1	2	29
Average	2	4	3	2	3	12	3	6	1	0	36

Total number of rigs building in Indiana in 1897, by counties.

Month.	Adams.	Black-ford.	Grant.	Hunt-ington.	Jay.	Wells.	Madi-son.	Mi-ami.	Ma-rion.	Dela-ware.	Total.
January	11	5	0	3	2	8	0	0	0	0	29
February	9	7	2	1	5	12	0	0	0	0	36
March	11	3	4	6	3	7	0	0	0	0	34
April	6	3	2	2	4	8	0	0	0	0	25
May	6	5	3	1	3	8	3	0	0	0	29
June	7	1	1	1	5	6	1	0	0	0	22
July	6	2	0	1	3	5	1	0	0	0	18
August	6	4	0	1	4	3	5	0	0	0	23
September	4	3	0	1	3	9	2	15	0	0	37
October	0	5	0	1	6	4	1	2	5	1	25
November	2	2	1	2	4	1	0	6	1	0	19
December	1	1	0	1	0	2	0	3	3	1	12
Average	6	3	1	2	4	6	1	2	1	0	26

In the following tables are given the records of wells completed in the Indiana oil fields from 1891 to 1897:

Number of wells completed in the Indiana oil fields from 1891 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891....	.....	.....	.....	.....	.....	.....	6	6	15	15	15	8	65
1892....	11	13	18	13	17	19	17	30	25	52	33	47	295
1893....	20	30	31	36	45	47	47	55	27	72	56	76	542
1894....	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895....	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896....	76	90	86	136	148	150	113	121	70	58	66	66	1,180
1897....	41	35	40	47	49	52	60	45	55	89	119	54	686

Initial daily production of new wells in Indiana oil fields from 1891 to 1897, by months.

[Barrels.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January..........	....	342	1,020	2,361	2,132	1,557	730
February	....	250	913	2,935	1,413	1,875	1,000
March	....	289	2,805	3,395	2,504	2,090	1,000
April	....	316	4,135	3,175	3,473	2,825	800
May	....	505	3,155	4,450	3,035	3,149	1,295
June.............	....	545	5,595	4,886	4,923	3,115	900
July	253	595	3,880	3,530	3,067	2,332	1,800
August...........	135	1,295	4,184	3,435	2,760	2,650	850
September	875	2,145	2,055	3,149	3,175	1,700	2,010
October..........	330	4,155	3,442	3,455	2,651	1,515	4,200
November.........	390	3,050	2,305	3,323	2,560	1,400	3,790
December.........	175	3,160	2,968	2,654	2,025	1,100	1,045
Average....	360	1,387	3,038	3,396	2,810	2,109	1,618

Total number of dry holes drilled in Indiana oil fields from 1891 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891....	....	....	.....	.....	.....	.....	0	2	5	4	3	1	15
1892....	2	6	6	2	3	4	2	3	3	18	6	21	76
1893....	7	10	10	6	14	6	11	9	5	14	10	9	111
1894....	19	14	24	14	13	13	9	21	15	14	8	17	181
1895....	7	4	13	16	22	20	15	23	12	12	9	13	166
1896....	10	13	6	28	26	20	14	19	4	4	6	8	158
1897....	8	9	7	12	5	16	11	9	16	11	18	8	130

Number of wells drilling in the Indiana oil fields at the close of each month from 1891 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891....	....	....	.....	.....	.....	.....	5	13	12	8	4	12	9
1892....	17	15	11	12	13	16	11	16	23	23	26	24	17
1893....	24	19	22	18	20	28	29	45	27	50	36	50	31
1894....	63	71	37	56	60	61	71	64	58	62	62	58	60
1895....	66	52	62	82	112	101	109	110	103	102	78	81	88
1896....	97	80	90	99	99	88	88	52	47	45	43	52	73
1897....	38	35	30	33	35	39	34	29	48	40	45	29	36

Rigs building in the Indiana oil fields from 1891 to 1897, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891....	....	....	.....	.....	.....	.....	7	2	12	8	6	6	7
1892....	8	18	23	23	17	21	16	15	29	31	39	19	22
1893....	12	15	17	14	17	26	32	28	9	25	27	30	21
1894....	36	39	34	40	35	30	32	35	35	57	38	32	37
1895....	37	50	73	89	102	91	78	69	83	70	61	80	74
1896....	72	50	53	67	79	48	52	33	32	34	42	24	49
1897....	29	36	34	25	29	22	18	23	37	25	19	12	26

The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in Indiana in 1897:

Well record in Indiana in 1897.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	41	730	8	38	29
February	35	1,000	9	35	36
March	40	1,000	7	30	34
April.................	47	800	12	33	25
May	49	1,295	5	35	29
June	52	900	16	39	22
July	60	1,800	11	34	18
August...............	45	850	9	29	23
September	55	2,010	16	48	37
October	89	4,200	11	40	25
November............	119	3,790	18	45	19
December	54	1,045	8	29	12
Total	686	*a* 1,618	130	*a* 36	*a* 26

a Average.

In the above table the producing wells are found by subtracting the dry holes from the wells completed, and as there were 686 wells completed and 130 dry holes, the number of producing wells were 556.

KENTUCKY.

The oil fields in this State were discussed under the head of "Appalachian production." Owing to the numerous failures of deep wells drilled in southern-central Kentucky, given in detail in last year's report, and the failure of many wells located on surface indications, very little new work was done during 1897. Wayne, Pulaski, Barren, and Cumberland counties have some wells that could be operated at a small profit if transportation by pipe line could be secured. They have a combined production of about 600 barrels per day, but they are scattered over a large area, and some of the oil is of inferior quality.

In eastern Kentucky, mostly in Floyd County, about fifty wells have been drilled since 1892, and twelve wells were completed and only indifferent shows of oil obtained during 1897. One of these wells, in Martin County, was a fair gas well. In the Beaver Creek section of Floyd County there are several small producing wells that get their oil in the sand above the "Big Lime" Mountain limestone. These are isolated from any means of transportation. In the latter part of the year two large tanks for the storage of this production were commenced about 15 miles above the mouth of Beaver Creek. This oil has a specific gravity of 41½° Baumé. It is of a dark-green color by reflected light and yellow by transmitted light. The wells are from 1,000 to 1,200 feet in depth.

PRODUCTION.

The total production of oil in Kentucky, so far as has been ascertained, is as follows:

Production of petroleum in Kentucky from 1883 to 1897.

[Barrels.]

Year.	Production.	Year.	Production.
1883	4,755	1891	9,000
1884	4,148	1892	6,500
1885	5,164	1893	3,000
1886	4,726	1894	1,500
1887	4,791	1895	1,500
1888	5,096	1896	1,680
1889	5,400	1897	322
1890	6,000		

The production shown for 1897—322 barrels—does not really include all of the petroleum produced, but represents the oil sold and delivered on board cars at Glasgow, Barren County. In a foot note under the head of Appalachian production it is shown that 4,377 barrels of petroleum were produced in Kentucky and Tennessee, none of which was sold, and as no price could be quoted it was excluded from the total production. How much of this amount should be credited to Kentucky could not be ascertained.

TENNESSEE.

Very little remains to be added to the statements made in the discussion of the Apalachian oil field in the preceding portion of this report regarding the production of petroleum in this State. The Bobs Bar well is the only producing well in this State. At the end of 1897 it was still producing at the rate of 17 barrels a day. Most of this oil is stored in the two large iron tanks erected in 1896 at Spurriers, in Pickett County, 5 miles below the Bobs Bar well, and is 30 miles from a railroad, to which point a pipe line must be constructed before the oil can be marketed. The combined production from Tennessee and Kentucky in this section has been placed at 4,377 barrels for 1897. Many efforts have been made to tap this same stratum of oil that feeds the Bobs Bar well, but all of the wells put down in this immediate neighborhood have been dry.

All of the large oil companies have abandoned this part of Tennessee and Kentucky, and surrendered many thousands of acres of leases to the original owners. There are some indications of oil in Alabama, but so far there has been little work done.

MISSOURI.

The production in this State comes from Bates County and is valued highly as a lubricating oil. The supply is irregular, and notwithstanding the price rose from an average of $4.30 in 1896 to $9.16 in 1897, only 19 barrels were produced in the latter year.

In the following table is given the production of crude petroleum in Missouri from 1889 to 1897:

Production of petroleum in Missouri from 1889 to 1897.

Year.	Barrels.	Year.	Barrels.
1889	20	1894	8
1890	278	1895	10
1891	25	1896	43
1892	10	1897	19
1893	50		

ILLINOIS.

The production in this State continues to come from Litchfield, Montgomery County. There are five or six wells producing a dark natural lubricating oil of 22° Baumé. The output was doubled in 1897 as compared to 1896. The price dropped from $5 a barrel in 1896 to $4 a barrel in 1897.

The production of petroleum in this State since 1889 has been as follows:

Production of petroleum in Illinois from 1889 to 1897.

Year.	Barrels.	Year.	Barrels.
1889	1,460	1894	300
1890	900	1895	200
1891	675	1896	250
1892	521	1897	500
1893	400		

INDIAN TERRITORY.

Two companies produced crude petroleum in this Territory in 1897, the Cherokee Oil and Gas Company and the Creek Oil and Gas Company, each producing a small amount. Several productive wells were drilled by the Cherokee Oil and Gas Company during the year, but owing to lack of facilities for transportation the wells were pumped only a short time. The oil produced by this company is of a lubricating character, and is found at an average depth of 280 feet in what is called the Bradford sand. The wells of the Creek Oil and Gas Company are at Muskogee. It is reported that developments will be begun on a more extensive scale in this vicinity during the year 1898.

PRODUCTION.

From the following table it will be seen that in this Territory the production of crude petroleum is on the increase, and the prospects are that 1898 will show a proportional gain over 1897.

Production of petroleum in Indian Territory from 1891 to 1897.

Year.	Barrels.	Year.	Barrels.
1891	30	1895	37
1892	80	1896	170
1893	10	1897	625
1894	130		

CALIFORNIA.

This State has a position next to Indiana in the amount of petroleum production. There was an increase of 750,634 barrels, equivalent to 51.93 per cent, in the output of crude petroleum in 1897 over 1896. The production for 1897 was 1,903,411 barrels, as compared with 1,252,777 barrels in 1896. The average price for 1896 was 99 cents a barrel; that for 1897 was 90 cents a barrel, which gives a value of $1,713,102 for the output of 1897, as compared to $1,240,990 in 1896, showing an increase in total value of $472,112. The price of crude petroleum in Santa Barbara County was 80 cents a barrel, in Santa Clara County $2 a barrel. The year 1897 was one of considerable activity, although the price has had a downward tendency. Crude petroleum is found in Los Angeles, Santa Barbara, Orange, Santa Clara, Ventura, Fresno, and Kern counties. In Humboldt, Mendocino, and Sonoma counties there are numerous oil springs. Los Angeles County produced 70 per cent of the total output of the State. Ventura County produced nearly 20 per cent of the total. Santa Barbara produced about one-third as much as Ventura County. Fresno County is credited with producing 70,000 barrels in 1897.

The petroleum found in Los Angeles, Ventura, and Santa Barbara counties is heavy; some of it is as low as 16° Baumé, others range up to 33° Baumé. It contains only a trace of paraffin and is classed with those of an asphalt base. Other oils found in Fresno and Santa Clara counties are lighter. The Coast Range, extending in a general way parallel to the Pacific Ocean, bounds the oil region on its west flank, and the great central valley of California bounds it on the east flank. This general range is cut through at San Francisco by a great arm of the ocean. On the flanks of this range, beginning near the southern extremity of the State and extending as far north as Humboldt County, numerous deposits of oil and solid bitumen have been found.

The Coast Range and its foothills are composed almost entirely of newer sedimentary rocks of great thickness, extending from newer Cretaceous, through the Eocene, Miocene, and Pliocene, to the Quaternary. There are numerous deposits of sand, more or less compact, interstratified with clay shales, and calcareous strata and conglomerate sandstone; also beds and isolated pieces of gypsum concretions. This immense deposit of sedimentary strata has been more or less folded and in some cases completely overturned, and the general range has many fingers reaching out into the plain at all angles. In many instances the folding has not been sufficient to prevent the formation of uninterrupted anticlines and synclines several miles in extent.

Los Angeles County has three oil fields that produced in 1897 as follows, as reported by the State mining bureau:

Oil product of Los Angeles County, California, in 1897.

	Barrels.
City of Los Angeles	1,073,011
Pico Canyon New-hall	145,000
Puente oil field	95,000
Central Oil Company, Whittier	14,000
Santa Fe Springs	12,000
Total	1,339,011

In Los Angeles the first oil that was marketed came from the old shaft owned by Mr. E. L. Doheney in the summer of 1893. The oil was found at a depth of 145 feet. The location of the well was near the intersection of West street and Lake Shore avenue, and its production was never more than 2 to 3 barrels a day. The producing area now extends from the elevation east of West Lake Park to the Catholic cemetery on Buena Vista street, a distance of about 3 miles. There is an extension toward Alpine street a distance of 3 blocks.

Early in 1897 a new field was discovered about 1 mile north of the town, which added considerably to the output. Late in the fall a new well came in 1 mile west of the extension heretofore mentioned in that direction. It is estimated that there were 700 to 800 wells producing in this field in 1897. In the old field the specific gravity of the oil is 15° Baumé to 17° in the new, and in some instances oil as high as 20° is found. The wells are from 750 to 1,100 feet deep, and usually require one string of casing. The cost of drilling is 60 to 80 cents per foot.

A large proportion of this crude petroleum is used as fuel. The Santa Fe Railway Company uses about 25,000 barrels a month; 80,000 barrels are used annually in the manufacture of beet sugar, and a large amount is refined. Asphaltum is extensively manufactured. The demand has so far kept pace with the supply. The high price of coal on the Pacific coast enables oil at a comparatively high price to find a market. There are no flowing wells in this region; all have to be pumped. A few produce from 50 to 70 barrels a day, but the greater number yield only from 2 to 5 barrels a day.

In 1897 Ventura County, west of Los Angeles County, produced 368,228 barrels of petroleum. which came from about 400 wells. On the southern slope of Sulphur Mountain there are about 30 tunnels, driven from 200 to 800 feet into nearly vertical strata, and which produce about 10,000 barrels of petroleum annually. A large amount of sulphur water and some gas escapes with the oil. The Union Oil Company has connected nearly all the wells and tunnels in this county with Sespe by pipe lines, there being over 100 miles in their system. Between Sespe and Ventura 4-inch pipe is used. Some of the wells when they first tap the sand flow from 500 to 800 barrels. When the flow ceases they pump one-tenth that amount, and in the course of two to three years they cease to produce enough oil to pay for the pumping.

Santa Barbara County adjoins Ventura on the east and is bounded on the west and south by the Pacific Ocean. Nearly all the petroleum produced in this county comes from Summerland, a few miles east of the city of Santa Barbara. The early explorers of this section found the original inhabitants using the asphaltum cast up by the sea. There are now a number of oil derricks, built at low tide and set up on posts, 10 to 12 feet long, and underneath the derrick floor at high tide there is 6 to 8 feet of water. These wells are pumped by rod connections operated by an engine on the shore. The production in this county, as reported by the State mining bureau, was 130,136 barrels, which is a large increase over 1896. There is also a large amount of asphalt manufactured at this place.

In Fresno County the oil field is located on the eastern slope of the Coast Range, nearly midway between Los Angeles and San Francisco, being 8 miles north of Coalinga. Although petroleum has been known to exist in that neighborhood for years, it is only a little over a year since active operations began in that section. The production for 1897 is placed, in round numbers, at 70,000 barrels. There were seven wells producing during the latter part of the year. The depth of the wells ranges from 600 to 900 feet, and two pays are usually found, one 200 feet above the other. An oil as light as 43° Baumé is found in the first sand. The gravity of the lower sand oil is 35° and constitutes the greater part of the production. One or two wells in this locality have produced a dark, heavy oil. One of the best wells in this field produced 160 barrels a day when first struck, but was down to 90 barrels in seven months. During the fall of 1897 a 6,000-barrel iron storage tank was built near these oil wells. There is a 2-inch pipe line about 9 miles long, reaching to the railroad, where there is a small storage tank. There is a fall of 500 feet from the large tank to the railroad. The following is an analysis of the oil found in this part of Fresno County:

Composition of petroleum from Fresno County, California.

	Per cent.	
Kerosene	47 to	48
Gasoline	18	20
Heavy fuel oil	13	10
Benzine and tar	22	22
Totals	100	100

It is difficult to make a good article of illuminating oil from California petroleum, for it is almost destitute of paraffin.

The strata along these foothills are more or less inclined and are composed of sharp anticlines and synclines. The flanks of these folds can not be traced for any great distance; there has been some faulting, but generally there is a series of elongated domes whose flanks are more or less confused.

Production of petroleum in California.

Year.	Barrels.	Year.	Barrels.
Previous to 1876	175,000	1887	678,572
1876	12,000	1888	690,333
1877	13,000	1889	303,220
1878	15,227	1890	307,360
1879	19,858	1891	323,600
1880	40,552	1892	385,049
1881	99,862	1893	470,179
1882	128,636	1894	705,969
1883	142,857	1895	1,208,482
1884	262,000	1896	1,252,777
1885	325,000	1897	1,903,411
1886	377,145		

COLORADO.

The production of Colorado in 1897 was 477,499 barrels as compared with 361,450 barrels in 1896, an increase of 116,049 barrels, or 32.11 per cent. The average price for the product in 1897 was 81 cents a barrel as compared with 88½ cents in 1896.

Several prospectors operated in this State during the past year, and the producing territory widened to the west. The petroleum is found at a depth varying from 1,200 to 2,200 feet in black shale, which is from 500 to 1,500 feet thick. So far as it was possible to ascertain, there were at the close of 1897 sixty-six producing wells in the Florence field. During the year 15 productive wells were completed, 25 dry holes were drilled, and 2 wells abandoned.

There was some demand during the year for crude oil and residuum for roasting ores in the smelters of Leadville, Pueblo, and Florence, where the cyanide and chlorination processes are used in extracting the precious metals from their ores.

The oil has a specific gravity of about 31° Baumé, and yields about 35 per cent of illuminating oil, 12 per cent naphtha and gasoline, and 53 per cent of residuum.

The following table gives production by months during 1896 and 1897:

Production of crude petroleum in Colorado in 1896 and 1897, by months.

[Barrels of 42 gallons.]

Month.	Production.		Month.	Production.	
	1896.	1897.		1896.	1897.
January	31,846	30,671	August.......	31,453	49,942
February	28,699	31,131	September ...	30,872	46,783
March	29,938	32,439	October	29,669	43,913
April.........	31,506	29,943	November....	27,909	41,518
May..........	30,911	36,311	December	27,218	42,967
June..........	30,188	42,207	Total ..	361,450	477,499
July	31,241	49,674			

In the following table will be found a statement of the production of crude oil in Colorado from 1887 to 1897:

Product of crude oil in Colorado from 1887 to 1897.

Year.	Barrels.	Year.	Barrels.
1887	76,295	1893	594,390
1888	297,612	1894	515,746
1889	316,476	1895	438,232
1890	368,842	1896	361,450
1891	665,482	1897	477,499
1892	824,000		

TEXAS.

The production of petroleum in this State increased from the insignificant amount of 1,450 barrels in 1896 to 65,975 barrels in 1897, an increase of 64,525 barrels, amounting to 4,450 per cent; in other words, for 1 barrel produced in 1896 there were 45½ barrels produced in 1897. The production for 1895 was only 50 barrels. It is produced in four counties, namely, Navarro, Jefferson, Hardin, and Bexar. Nearly the entire production comes from Navarro County, near the town of Corsicana, about 50 miles southeast of Dallas.

At the close of 1897 there were 43 wells, of which number 6 were nonproducers. The oil is found in a loose sand deposit from 20 to 30 feet thick. Before the sand is penetrated the drill passes through a homogeneous blue clay, known as ponderosa or joint clay, which crumbles to dust on exposure to the air. This is in the marls of the Upper Cretaceous, above the horizon known as the Austin chalk. The average production per well is from 15 to 18 barrels a day, but some wells have started off at 50 barrels a day. Some wells have been put down by a rotary drill. The bit, with projecting wings, is secured to the end of the tubing, and water is pumped through it, escaping out of the sides of the bit and washing up the loosened material on the outside of the tubing to the surface. This is a rapid and cheap method of sinking wells and is generally successful, unless solid rock or bowlders are encountered, but is objectionable owing to the heavy water pressure put on the oil sand in drilling in it.

The sand is almost pure silica, although dark gray in color, and contains foraminifera of several kinds, among which are Rotalia, Nomionina, and Globigerina. Some of the foraminifera correspond to those found in the chalk beds of Europe, and others resemble those found in the oil sands of Galicia. In the early history of this field nearly all the wells flowed, but latterly they have to be pumped; and as there is considerable loose sand, it has been found difficult to keep the leather cups from cutting. To prevent this, compressed air is carried down to the bottom of the well in a small pipe and allowed to escape through the tubing, a device which has been used with some success. Nearly all the machinery used is portable, and 4½-inch casing is put in nearly to the bottom of the hole. The cost of a well is in the neighborhood of $1,500.

The developments so far do not cover a very large area, all efforts to extend the field having been thus far unsuccessful. The oil is dark in color and has a specific gravity of from 0.833 to 0.824, or 38° to 40° Baumé. It yields a large amount of illuminating and lubricating oils of good quality, although most of it has been used for fuel in a part of the State where other fuel is scarce. Since the 1st of January, 1898, nearly all the oil produced has been sold to the J. S. Cullinan Pipe Line and distributed to consumers by this pipe line and storage system.

In Jefferson County, at Sour Lake, there is an oil found of a dark green color. It is very heavy and comes from a soft, disintegrated sand underlying limestone bowlders. Its gravity is 16½° Baumé as it comes from the wells. It is a good natural lubricator, and is used in a number of mills in its natural state. There are three wells in this locality capable, it is said, of producing 100 barrels a day. Only one is now working, which is making 35 barrels a day.

In a small test refinery that was destroyed by fire in January, 1898, eight different grades of oil were made of the heavier gravities. No kerosene was made, but 30 per cent of headlight oil was secured, a valve oil of 12° gravity, and an engine oil of 22° gravity. The Gulf Coast Refining Company is now erecting a refinery having a capacity of 75 barrels a day.

Bexar and Hardin counties produce a dark, heavy oil in limited quantity, used for lubricating purposes in its natural state. There are a number of other places in the State where dark, heavy, tarry oil and bitumen are found. At Cline, Uvalde County, a limestone deposit containing a large percentage of bitumen is extracted, and a peculiar flexible bitumen is manufactured.

The following is taken from an article written by Mr. Thomas D. Miller and presented to the Engineers' Club of St. Louis, May, 1898:

HISTORY OF TEXAS PETROLEUM.

The first development of oil in Texas was near Nacogdoches, about thirty years ago, when oil was found at Oil Spring, about 15 miles south of the town. Nearly 100 wells were sunk at the time and oil was found at a depth of about 100 feet. It is said that the yield of the first well was nearly 300 barrels the first day, and that it did not flow after that; but few of the succeeding wells flowed and the oil was either bailed or pumped. A pipe line was built to the railroad and a 2,000-barrel storage tank erected. Upon examination of this product it was found to be unsuited for the manufacture of illuminating oil, and the industry was prosecuted no further. This oil, which is of high gravity, is well adapted to the manufacture of lubricating oils. These heavy oils are known to exist in other localities in the State, but no development of the fields has yet been undertaken to any extent. All the petroleum in Texas yet examined has an asphaltum base, and it would seem but natural that such should be the case, as asphaltum deposits are found distributed over a large territory in the western, northwestern, and northern part of the State and in the Indian Territory. About many of these deposits a heavy asphaltic oil is observed exuding from the ground.

Oil was discovered at Corsicana some time prior to 1894 by Maj. Alex. Beaton while sinking an artesian well. In 1894 the city of Corsicana sunk an artesian well for a water supply, and at 1,027 feet struck an oil vein. The oil was cased off and the boring continued to a depth of 2,470 feet when a good flow of warm water was encountered, but no more oil. The oil, however, soon made its appearance through the soil on the outside of the casing and has flowed continually since. On this evidence of oil a company was formed and wells were sunk, which vary in depth from 1,000 feet to 1,040 feet to the top of the oil-bearing sand, which is from 10 to 40 feet thick. The oil rock lies very regularly and dips to the southeast about 1 foot in 100. After oil is struck it usually requires about twenty-four hours for it to reach the surface; it is forced up by gas, and in several wells it has spouted out 100 feet above the ground. The flow seems to be by heads of from five to ten minutes duration, followed by a short period of complete cessation. There is also a diurnal period in the strength of the discharge, commencing about 4 p. m. and gradually increasing up to midnight, then diminishing until 9 a. m. The wells produce from 10 to 30 barrels per day each. Some of the wells on the edge of the field have fallen off considerably, but those in the middle of the known oil-producing area have held their yield well. The older wells, among the best producers, showed practically the same yield when one year old as when new.

There are now over 100 producing wells and some of them not over 200 feet apart, and still there is no appreciable diminution in the flow of the individual wells. Before pumping was begun the total flow of oil was about 900 barrels per day. Recently pumping was commenced and, as the result of this is not given out, as rather an inclination to secrecy is apparent, it is impossible to say positively what quantity of oil is being produced with the pumps. Out of the total number of wells drilled not quite 10 per cent have proved nonproducers, or dry holes. The field in which oil is known to exist is about 2½ miles long, bearing northeast and southwest 20° to 22°, by 1 mile wide. At this time a regular system of drilling, called "wildcatting" is going on for the purpose of determining the exact extent of the oil field. These wells have not as yet shown oil outside of the territory named, but they have established the existence of an extensive gas field. One well sunk, 9 miles northeast of the town, near Chatfield, encountered at a depth of 862 feet a strong flow of natural gas, which rushed out with such force that the fire in the boiler had to be extinguished to prevent the destruction of the plant. Another wild-cat well, one mile south of the Union Depot in Corsicana, struck a strong flow of gas at a depth of 1,040 feet. The static pressure of the gas in this well was over 200 pounds. Several other wells, about 3 miles southwest of town, have also reached the gas-bearing sand. About 70 miles south of Corsicana a gas well has been flowing for several years, which would seem to indicate that the territory in which gas can be reached is quite extensive.

The elevation of Corsicana is about 800 feet above the sea; therefore the oil-bearing strata is something over 200 feet below sea level. The drilling is entirely through ponderosa marl.[1] The oil-bearing rock is soft gray shale and can hardly be called a sand. In January last a pipe-line company was formed and the entire output of nearly all the wells was contracted for. Storage tanks for over 60,000 barrels have been erected, and a refinery is now about to be built. At this time all of this oil that has been consumed has been used as fuel, with the exception of some used for gas making; but as there are few gas plants in the State and fewer water gas plants, the consumption for this purpose has been small. As a gas oil it gives very satisfactory results, yielding from 5.50 to 5.75 candles per gallon of oil used, and as high as 32 candle-power gas can be made with it.

A fractional distillation of Corsicana crude oil, made by Mr. E. H. Earnshaw, chemist for the United Gas and Improvement Company, showed the results given in the following tables. The oil is very dark brown and opaque, but thin and fluid at 60° F.; the specific gravity at 60° F. equals 0.8292 (39° Baumé).

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[1] A corrupted abreviation of *Exogyra ponderosa* marl

Results of distilling Corsicana petroleum.

Temperature. Degrees F.	L.		Degrees Baumé.	Specific gravity at 60° F.	Color, etc.
	Per cent by volume.	Per cent by weight.			
A—130 to 200	2.80	2.24	80.00	0.6653	Colorless.
B—200 250	5.10	4.31	69.50	.7017	Do.
C—250 300	7.60	6.69	61.75	.7302	Do.
D—300 350	8.20	7.44	56.00	.7527	Do.
E—350 400	9.40	8.75	51.25	.7718	Do.
F—400 450	7.40	7.07	46.75	.7920	Do.
G—450 500	8.30	8.09	43.00	.8088	Do.
H—500 550	6.45	6.43	39.50	.8260	Very faint yellow.
I—550 600	7.75	7.85	36.50	.8404	Do.
J—600 650	14.95	15.43	33.50	.8555	Yellow.
K—650 665	17.25	18.07	31.00	.8687	Deep reddish yellow.
L—above 665	1.30	1.41	26.00	.8972	Deep red—solid.
M—above 665	1.40	1.63	14.50	.9699	Dark red brown—solid.
Residue	....	2.63	....	....	
Total	97.90	98.04	....	....	

Summary of the foregoing fractional distillation.

Temperature. Degrees F.	Per cent by volume.	Per cent by weight.	Degrees Baumé.	Specific gravity.
130 to 200	2.80	2.24	80.00	0.6653
200 300	12.70	11.00	64.75	.7191
300 400	17.60	16.19	53.50	.7680
400 500	15.70	15.16	44.75	.8012
500 600	14.20	14.28	37.75	.8345
600 665	32.20	33.50	32.25	.8627
Above 665	2.70	3.04	19.75	.9350
Residue	....	2.63	....	....
Total	97.90	98.04	....	....

The production of petroleum in Texas since 1889 has been as follows:

Production of petroleum in Texas from 1889 to 1897.

Year.	Barrels.	Year.	Barrels.
1889	48	1894	60
1890	54	1895	50
1891	54	1896	1,450
1892	45	1897	65,975
1893	50		

KANSAS.

The production in Kansas in 1897 was 81,098 barrels as compared to 113,571 barrels in 1896, a decrease of 32,473 barrels, equivalent to 28.59 per cent. The large percentage of dry holes drilled and the decrease in the output of wells producing for the past year have been very disappointing to those operating. A detailed statement of the number of wells drilled could not be obtained.

The total product of oil in Kansas, so far as records have been obtained, is as follows:

Production of petroleum in Kansas.

Year.	Barrels.	Year.	Barrels.
1889	500	1894	40,000
1890	1,200	1895	44,430
1891	1,400	1896	113,571
1892	....	1897	81,098
1893	18,000		

WYOMING.

The production of crude petroleum in Wyoming in 1897 was 3,650 barrels, as compared with 2,878 barrels in 1896, an increase of 772 barrels, equal to 26.82 per cent. The oil belt extends diagonally across the State. The principal part of the production is 60 to 80 miles from Casper, the present terminus of the Northwestern Railroad system, and is about 5,000 feet above the level of the sea. There was a large outlay for transporting machinery and material. In most of the localities where oil has been developed there is ample water for all purposes, and in several instances natural gas can be secured for fuel. There are several companies operating in this field. The lands of the Pennsylvania Oil Company are located on Salt Creek, a tributary of the Powder River in northern Natrona and southern Johnson counties. In this locality eight wells have been drilled, seven of which have a large capacity, if the oil could be disposed of and the wells allowed to flow. These wells are about 1,200 feet in depth. A refinery at Casper, with a delivery capacity of 60 barrels a day, is owned by this company.

The Cudahy Company owns a large tract of land joining that of the Pennsylvania Company, on which they are drilling. The Wyoming Lubricating Oil Company has also drilled one or two wells. The Murphy wells on Little Popo Agie River, in Fremont County, are so far from railroad transportation that it is difficult to market their product. These wells are gushers, but are shut in at present. There is no doubt that with proper facilities for transportation Wyoming could furnish a very much greater production of superior lubricating oil. The price is still quoted as $8 per barrel, which is nearly double the price quoted for any other natural lubricating oil.

The following table gives the production for the past four years:

Production of petroleum in Wyoming from 1894 to 1897.

Year.	Barrels.
1894	2,369
1895	3,455
1896	2,878
1897	3,650

A considerable amount is wasted annually at the wells shut in in the Popo Agie field.

Prof. W. C. Knight, of the School of Mines, University of Wyoming, recently examined the Popo Agie, Lander, and Shoshone fields, which extend continuously in a northwesterly direction through Fremont County. From his Bulletin No. 2 the following extracts are taken:

The Popo Agie oil field.—The oil wells of the Popo Agie oil field are located on the Little Popo Agie River, 10 miles southeast of Lander, the county seat of Fremont county, at an elevation of 5,350 feet above sea level. The oil field extends north and west to within 4 miles of Lander, covering a distance of 12 or 15 miles. Its width varies greatly and can not be accurately given since there are no data to guide one in making an estimate. On the east side it may be possible to drill and reach the oil horizon 3 miles from the axis of the anticlinal, but 2 miles away will necessitate drilling to a much greater depth than it is usual to drill for oil. On the west side the field may be extended as far as the base of the White River Mountains, but it is probable that the limit will be found within a distance of 3 miles west of the anticlinal.

The surface of the central portion of the oil field is very rough and broken, and is cut into deep gulches with precipitous hillsides. Along the eastern and western borders the country is more rolling and marked with ledges of sandstone and shale that form ridges paralleling the anticlinal. This district is at present over 100 miles from any railroad. * * *

In 1881 Dr. Graff, of Omaha, and associates purchased the oil claims and did considerable surface work. In 1883 and 1884 they drilled three oil wells, all of which were producers. The company then purchased a large number of iron barrels and commenced to market the oil at the Union Pacific Railroad. On account of keen competition of the eastern oil producers the first Wyoming oil company had to abandon its enterprise. Since that time the wells have remained packed. The oil that flowed from the wells through leaks has been utilized by the ranches for miles about for lubricating purposes, and to some extent by the gold mines and the flour mills for steam making.

The geology of the field is of special interest, since the oil is found in the Paleozoic strata, and in this respect it resembles more closely the oil fields of the Eastern United States than any other Rocky Mountain oil field. The structure of this field is an anticlinal, with the rocks dipping gently to the east and very abruptly to the west. The axis of the anticlinal from a point nearly east of Dallas post-office to near the northern limit of the field has suffered heavy erosion, and is now an anticlinal valley, averaging a quarter of a mile in width, through which the Little Popo Agie River flows. The thickness of the rocks removed from the anticlinal aggregate 10,000 feet, since it represents a nearly complete series of the Rocky Mountain Mesozoic. In the vicinity of the oil wells the river has cut down nearly through the Triassic sandstone, but in no instance was Carboniferous rock found exposed. The Triassic rocks of this field are composed of red sandstone, with a band of drab marble near the base and a band of gypsum 50 feet thick near the top. The thickness of this formation is nearly 1,000 feet. The Jurassic rocks are made up of three distinct bands. The lowest is the marine beds; the middle a band of light-colored sandstone, and the upper, various colored marls, making in all about 300 feet. The Dakota group, the basal member of the Cretaceous, does not contain the heavy band of conglomerate that is usually seen in central Wyoming. It is composed of light-colored sandstone and shale and has a thickness of about 350 feet.

The Fort Benton group was not studied, but it has a normal development and is characterized by the typical band of shales. On the east side of the anticlinal the red sandstone dips 17° north of east and rises rather abruptly 500 feet, but the greatest elevation is reached about 1 mile from the axis, where the Dakota sandstones form a very high and prominent ridge. Farther to the east can be seen successive bands of the upper Cretaceous groups, and in the distance thick beds of Wasatch and Bridger Eocene. On the west side of the anticlinal the rocks change to dip very rapidly; in the distance of a quarter of a mile they change in dip from a few degrees to 70° south of west, but suddenly flatten to form the Lander synclinal. Owing to the vast quantity of rock removed from the west side of the field by erosion it is possible to drill and reach the oil horizon at any point west of the anticlinal and east of the Wind River Mountains. * * *

Up to the present time the exact position of the oil horizon has not been determined, as the records of the wells have been lost. Beyond question the source of the oil is the conglomerate and the magnesian limestone below, found 150 feet below the contact of the Triassic and Carboniferous formations.

Along the axis of the Shoshone anticlinal in this district there is developed a series of domes. The dip along the line of the axis is often from 6° to 10°. The Murphy wells are located on one of these domes.

It is estimated that 4,000 barrels go to waste annually at these wells, as they all allow oil to escape badly. From the most reliable data obtainable the production of these wells has been estimated at 200 barrels each if pumped. The elevation of the well and the dips have caused the difference in the depths of these wells.

The Lander oil field.—The Lander oil field joins the Popo Agie field on the northwest and extends along the Shoshone anticlinal to within 5 or 6 miles of Fort Washakie. All of this district lying northwest of the Big Popo Agie River is on the Shoshone Indian Reservation and consequently can not be developed until the Government has purchased the land. On the reservation the anticlinal is very prominent near the river, but to the northwest the red sandstones and Jurassic rocks suddenly disappear, and only the Fort Benton shale and groups above can be seen. This disappearance is due to heavy erosion and subsequent heavy deposition of loess. * * * The width of this part of the field will not vary much from the Popo Agie, but from the conditions known the western side will be fully as valuable for oil as the eastern. * * *

The only place where oil was seen coming from the rocks was at a point about 3 miles north and west of the Big Popo Agie River, at the termination of a bluff of typical Fort Benton shale.

The source of the oil is unquestionably below the shale band, and will probably be found in the Dakota sandstone. * * * On account of this oil field lying mostly within the boundaries of the reservation there has been no development.

The Shoshone oil field.—This field includes the northern extension of the Shoshone anticlinal and joins the Lander on the south. The Little Wind River has cut its way across the anticlinal, and on either side of the broad valley can be seen the upturned Triassic sandstones, and to some extent higher groups of rocks. On the southeast side of the Little Wind River the axis of the anticlinal forms a broken bluff with slight exposures of higher rocks, but only a mile away all of the rock mass is covered with loess. On the north side of the river the apex of the fold has been cut away by erosion and is now a broad valley extending nearly a mile to the north. On the east the red sandstones, dipping about 15° to the east, form the boundary, and beyond can be seen the prominent bands of Jurassic and Lower Cretaceous groups. On the west side the Upper Triassic, Jurassic, and Lower Cretaceous groups are dipping from 80° to 89° to the west. The thickness of the various geological formations in this field is about the same as seen in the Popo Agie, and they also resemble each other very closely in texture. In fact, the geological features of the two fields are almost identical. The most prominent oil spring is located in the alluvial basin along the axis of the anticlinal, about 500 yards northeast of the ford on the Little Wind River which is used by the Government as a crossing from their stone quarry. The oil spring, which originally was in the loess, is now surrounded by a bed of asphaltum that measures 50 by 100 yards, and is from a few inches to 3 feet in thickness. The oil escapes at several places, together with gas and water; but there are no pools to hold it, and in consequence it was impossible to secure any oil that would represent the nature of the petroleum that would be found by drilling. This spring appears to come from a fracture very near the axis of the anticlinal. The thickness of the Triassic rocks exposed on the east side of the basin signifies that nearly all of the Triassic sandstone must have been removed from the apex of the uplift. The source of the oil is Upper Carboniferous, the same as in the Popo Agie field, and it is very likely that a drill sunk to the depth of 500 feet to the east of the oil spring would strike oil. The pretroleum, as it escapes from the spring in small globules, has the same odor and color as the Popo Agie oil. On the south side of the Little Wind River, where a small stream cuts into the Triassic sandstone, there were a few drops of oil rising to the surface, but on account of the water no study was made of the escape. The productive portion of this field will be similar in extent to that of the Popo Agie. The western limit may not be so extensive, and can not be easily determined, since most of the Cretaceous rocks are covered and there is no way of estimating their probable thickness. This field, being wholly on the reservation, has never received any attention, and can not until the land passes into other hands.

Analysis of Wyoming petroleum.—The following facts concerning the Popo Agie, Lander, and Shoshone petroleum have been derived from the same bulletin, the analysis having been made by Prof. Edwin E. Slosson:

The Popo Agie petroleum is almost black, although in thin layers it is reddish brown by transmitted light. There is no perceptible fluorescence. The odor is strong and disagreeable. The percentage of sulphur in the crude oil is 0.66, about the same as in the Lima, Ohio, petroleum. The specific gravity is 25.5° Baumé (0.900). The crude oil flashes at 90° F. (32° C.) and ignites at 136° F. (58° C.) It is still fluid at 14° F. (−10° C.) The viscosity at 20° C., compared to water at the same temperature, is 13.28. The heating power of the Popo Agie petroleum, as determined by the bomb calorimeter, is 10,437 calories per gram, which is equivalent to 14,571,000 foot-pounds of energy per pound of oil. One pound of oil will give heat enough to convert 19.40 pounds of water at 212° F. into steam, equal to 18,740 B. T. U. The crude oil shows no paraffin on cooling and is soluble without residue in light benzine. Absolute alcohol leaves a tarry residue and deposits paraffin on cooling.

Analysis of Popo Agie petroleum.—Very elaborate tables, showing the composition of Popo Agie oil, and its weight, specific gravity, viscosity, and flashing, burning, and freezing points, as determined by Prof. Edwin E. Slosson, are omitted for lack of space. The commercial products of the oil are as follows:

Distillation products of Popo Agie petroleum, Wyoming.

	Per cent.	
Naphtha (gasoline)	2 to	5
Kerosene (0.810 to 0.830)	30	40
Lubricating oil (0.910 to 0.940)	35	50
Paraffin	3	5
Coke	7	10
Gas	10	12

Analysis of Lander petroleum.—A small quantity of oil collected at the Washakie spring gave the following results: The sample had a specific gravity of 0.8565 (33° Baumé) and viscosity of 0.94. It flashed at 99° F. (37° C.) and burned at 113° F. (45° C.). It is bright red by transmitted and green by reflected light. Analysis shows that this oil is entirely different from the Popo Agie oil. It is very much lighter than most of the Wyoming oils, and probably the oil from a well would be still lighter than the oil from the spring. The oil distills without much decomposition until the temperature rises to about 365° C. Even at this heat no perceptible amount of paraffin or gas is formed. The products, until about 50 per cent of the oil has come over, are very light-colored with little fluorescence. In working with large quantities of the fresh oil, probably 75 per cent, and possibly much more of the crude oil, could be obtained as kerosene or gasoline.

ALASKA.

Several Alaskan companies have located a large number of mining claims which, under certain conditions, include petroleum. Along the coast of Alaska, northwest of Sitka, beginning near Cape Yakutat, which is 500 miles northwest of Sitka and just west of Mount St. Elias, there are numerous natural springs of oil and water along the flank of the first range of foothills, from a mile to a mile and a half back from the ocean, and extending for 25 miles northwest, in a line parallel to the coast. This range of foothills, whose elevation is from 500 to 600 feet, is cut through by many small streams, and along these streams, near the axis of the range, numerous oil and water springs exist. Seventy-five miles farther west along the coast, between Cape Suckling and Cape Martin, there are also springs showing oil and sulphur water, and still farther inland there are deposits of coal.

There are also some slight indications of oil 75 miles farther west, on the main land opposite Kachemak Bay, at the mouth of Cooks Inlet. All of these rocks are more or less disturbed, and the angles of dip are from 20° to 80°, generally not less than 30°, and have a vertical range extending from the lower Cretaceous into the Tertiary.

The character of the oil is similar in a general way to California petroleum and ranges from dark green to black in color, and from 27° to 35° Baumé in weight. The harbors in this section are poor, and landing is attended with more or less difficulty. The surrounding country is a wilderness.

FOREIGN COUNTRIES.

CANADA.

Notwithstanding the great number of square miles in Canada and British America, nearly all the petroleum produced in this vast region comes from southwestern Ontario. The field is of limited area and has for many years furnished a steady supply. Indications of petroleum are found over a large area extending from the Gaspe Peninsula to the Pacific Ocean, and for many miles toward the north on the waters of the Athabasca and Peace rivers, and in strata embracing almost the whole section of known sedimentary rocks, from the oldest to the newest. The production at Petrolia and Oil Springs continues with great regularity, although slightly under that of previous years. The production of so many thousands of barrels of oil in this comparatively small area of not over 18 square miles in both fields from shallow wells and a pay streak only a few feet in thickness is without a precedent.

A number of paying wells have been drilled toward Sarnia from Petrolia, and the productive area extended in that direction. These wells are small producers, ranging from 5 barrels to three-fourths of a barrel per day. They are from 375 to 420 feet deep, and are easily pumped in large clusters.

Pelee Island, in Lake Erie, has furnished a number of producing wells. There were thirteen producers on the island at the close of 1897. The oil is found in the Clinton limestone, which underlies the Niagara shale at a depth of 800 feet.

The region southeast of Oil Springs has been prospected over as far as Bothwell and Florence, and a number of fair producers for that section have been secured, although the number of dry holes has been in excess of the producing wells. The last year has been one of active prospecting. Some oil has been found in the Welland gas field in the Medina sandstone, but not in paying quantities.

In the Gaspe district, almost at the extreme eastern limit of the Province of Quebec, at which point the Appalachian Mountains are suddenly cut off by the sea, there are many oil springs and indications of oil. Near this locality a number of test wells have been drilled within the last two years and some shows of oil found, but nothing in quantity large enough to make a paying well has been reported. One of these wells was drilled to a depth of 3,000 feet, and samples of oil of good quality were found. A wide range of strata has been prospected over, extending from the Silurian up to the Lower Carboniferous, in close proximity to these oil shows.

PRODUCTION.

The Canadian barrel has 35 imperial gallons of 277.27 cubic inches, making 9,704.4 cubic inches; the United States barrel has 42 gallons of 231 cubic inches, making 9,702 cubic inches—a very slight difference. The imperial or Canadian gallon is 20 per cent, or one-fifth, larger than the United States gallon. The following table shows the shipments of crude petroleum and refined petroleum, reduced to crude equivalent, from Petrolia and Oil Springs, Canada, in 1896 and 1897:

Shipments of crude petroleum and refined petroleum reduced to crude equivalent from Canada in 1896 and 1897.

[Barrels of 35 imperial gallons.]

Month.	1896.			1897.		
	Crude.	Refined.	Crude equivalent.	Crude.	Refined.	Crude equivalent.
January	25,696	19,255	83.495	17,883	25,869	82,556
February	20,585	16,316	66,797	16,010	20,467	67,178
March	20,030	18,101	65,283	13,170	15,920	52,971
April	16,353	21,912	71,133	13,014	9,023	35,572
May	17,156	10,484	43,386	17,604	17,187	60,572
June	15,476	13,191	48,459	15,716	15,710	54,991
July	15,413	18,168	60,833	12,656	13,986	47,622
August	16,314	24,881	78,518	15,073	22,752	71,953
September	19,461	38,673	116,144	18,045	34,122	103,351
October	23,290	42,649	129,913	17,123	41,646	121,238
November	25,966	33,147	103,834	16,760	35,946	106,625
December	19,508	30,001	94,486	18,767	25,396	82,257
Total	235,248	286,778	962,281	191,821	278,024	886,886

The following table gives the shipments from the Petrolia oil field by railroad, in gallons, for each month:

Shipments of crude petroleum from the Petrolia (Ontario) oil field in 1894, 1895, 1896, and 1897.

[Barrels of 35 imperial gallons.]

Month.	1894.	1895.	1896.	1897.
January	101,570	89,462	83,495	82,556
February	76,183	83.497	66,797	67,178
March	60,661	66,943	65,283	52,971
April	73,463	60,287	71,133	35,572
May	67,369	64,120	43,386	60,572
June	57,830	59,982	48,459	54,991
July	69,586	62,410	60,833	47,622
August	86,345	78,173	78,518	71,953
September	109,973	102,309	116,144	103,351
October	156,163	141,787	129,913	121,238
November	122,513	101,100	103,834	106,625
December	97,170	102,115	94,486	82,257
Total	1,078,826	1,012,185	962,281	886,886
Shipped by pipe line	10,000	....	....	....
Total	1,088,826	1,012,185	962,281	886,886

Shipments of crude petroleum from the Petrolia (Ontario) oil field in 1894, etc.—Cont'd.

[Barrels of 35 imperial gallons.]

Month.	1894.	1895.	1896.	1897.
Stocks in tanks—				
January 1	77,000	40,898	27,987	33,560
December 31	40,898	27,987	33,560	44,562
Increase or decrease in stocks.	−36,102	−12,911	+5,573	+11,002
Approximate production.	1,052,724	999,274	967,854	897,888

Some oil was reported to have been shipped by pipe line in 1897, but the statistics are not available. Owing to the possibilities of duplication, Mr. James Kerr, of Petrolia, considers the production given above as too great by about 10 per cent, and estimates the production of 1894, 1895, 1896, and 1897 as follows:

Estimated production of petroleum in Canada in 1894, 1895, 1896, and 1897.

[Barrels of 35 imperial gallons.]

	1894.	1895.	1896.	1897.
Shipped by road	970,943	910,967	866,053	798,197
Shipped by pipe line	10,000	....	....	....
Total	980,943	910,967	866,053	798,197
Increase or decrease of stocks	−36,102	−12,911	+5,573	+11,002
Making the production	944,841	898,056	871,626	809,199

This represents the production to have declined 62,427 barrels in 1897 as compared with 1896. These statements refer to the production at Petrolia and Oil Springs. During 1897 there was considerable production, outside of the points named above, in this section of Ontario, which is estimated at 20,000 barrels for 1897.

In the following table is given a statement of production from 1886 to 1897 which is based on calculations furnished by the customs inspection returns, and the values are computed at the average yearly price per barrel.

Production and value of petroleum in Canada from 1886 to 1897.

[Barrels of 35 imperial gallons.]

Year.	Production.	Value.
1886	486,441	$437,797
1887	763,933	595,868
1888	733,564	755,571
1889	639,991	612,101
1890	765,029	902,734
1891	755,298	1,004,596
1892	779,753	982,489
1893	798,406	834,344
1894	829,104	835,322
1895	728,665	1,090,520
1896	726,822	1,155,646
1897	709,857	1,011,546

The average price paid for oil is given in the following table. Sales at the Petrolia Oil Exchange have ceased, producers now making sales direct to the refiners, who own a considerable part of the production.

Average price and sales of crude petroleum in Canada from 1885 to 1897.

Year.	Price.	Sales.
		Barrels.
1885	$0.82¼	871,500
1886	.86¾	782,570
1887	.78	406,203
1888	1.02¾	516,007
1889	.92¾	400,932
1890	1.18	394,924
1891	1.33¾	377,453
1892	1.26¼	165,315
1893	1.09½	20,941
1894	1.00¾	32,348
1895	1.49⅝	9,755
1896	1.59	0
1897	1.42½	0

The following table shows the price received by the producer from 1892 to 1897, inclusive, by months:

Average price of crude petroleum in Canada from 1892 to 1897, by months.

Month.	1892.	1893.	1894.	1895.	1896.	1897.
January	$1.29¼	$1.18¼	$1.01¼	$1.16	$1.72	$1.50
February	1.29	1.18¾	1.01	1.19⅞	1.72	1.50
March	1.27¾	1.19	1.01	1.27	1.72	1.50
April	1.26¼	1.19	.99½	1.55¾	1.71	1.40
May	1.25⅝	1.07	.92	1.67¼	1.70	1.40
June	1.27½	1.07	.92¾	1.52	1.50	1.40
July	1.26¾	1.06	.94	1.52¼	1.50	1.40
August	1.26	1.05	.96	1.54	1.50	1.40
September	1.26	1.04½	.98	1.55½	1.50	1.40
October	1.26¾	1.04	1.06	1.59⅞	1.50	1.40
November	1.25	1.04	1.12¼	1.64½	1.50	1.40
December	1.18½	1.02	1.13½	1.72⅝	1.50	1.40
Average	1.26¼	1.09½	1.00¾	1.49⅝	1.59	1.42½

The average decline in 1897 was 16½ cents per barrel, the price remaining the same for the last nine months of the year. The increase of price of Canadian oil over Lima (Ohio) oil is due to the protective duties levied on oil imported, which were as follows:

Canadian import duties on petroleum.

	Per barrel.
Crude petroleum, 3⅕ cents per imperial gallon	$1.12
Illuminating oil, etc., 7⅕ cents per imperial gallon	2.52
Lubricating oil, 6 cents per imperial gallon	2.10

The following statements, furnished by the Department of Agriculture, Ottawa, show the operations of the refineries in Canada from 1890 to 1897, inclusive:

Production of Canadian oil refineries from 1890 to 1897.

[Imperial gallons.]

Year.	Illuminating oil.		Benzine and naphtha.		Paraffin oils.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
1890...	11, 129, 277	$1, 264, 677	636, 247	$37, 026	446, 888	$64, 713
1891...	10, 427, 040	1, 170, 241	603, 971	36, 790	622, 287	75, 772
1892...	10, 806, 806	1, 176, 720	793, 263	60, 130	1, 051, 163	127, 351
1893...	11, 100, 810	1, 073, 738	721, 192	54, 760	1, 243, 924	116, 233
1894...	11, 289, 741	1, 003, 973	645, 031	54, 515	1, 282, 749	118, 053
1895...	10, 711, 378	1, 217, 426	642, 484	63, 026	1, 016, 039	140, 245
1896...	11, 207, 150	1, 251, 122	719, 453	70, 733	1, 014, 271	132, 308
1897...	10, 493, 449	1, 064, 130	747, 163	71, 978	930, 490	136, 283

Year.	Gas and fuel oils.		Lubricating oils and tar.	
	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*	
1890	4, 246, 447	$84, 752	2, 877, 388	$130, 349
1891	3, 373, 720	89, 267	2, 500, 000	101, 752
1892	6, 343, 589	202, 047	3, 177, 853	133, 336
1893	7, 559, 489	217, 740	1, 876, 633	92, 616
1894	7, 323, 374	197, 193	1, 801, 174	74, 309
1895	6, 095, 355	218, 692	1, 698, 559	75, 578
1896	6, 788, 353	261, 618	1, 447, 455	77, 109
1897	6, 723, 683	249, 615	1, 148, 847	62, 058

Production of Canadian oil refineries from 1890 to 1897—Continued.

[Imperial gallons.]

Year.	Paraffin wax.		Value of other products.	Total value.
	Quantity.	Value.		
	Pounds.			
1890	913,730	$56,903	....	$1,638,420
1891	741,611	60,687	....	1,534,509
1892	876,570	82,781	....	1,782,365
1893	1,659,167	120,697	....	1,675,784
1894	1,950,172	119,091	....	1,567,134
1895	1,840,021	82,970	$8,300	1,806,237
1896	1,532,670	76,249	7,774	1,876,913
1897	1,805,365	81,191	7,174	1,672,429

From the above it will be seen that the price obtained by the Canadian refiner for illuminating oil, 10.1 cents per gallon, was 20 per cent higher than in the United States. He received 3.7 cents per gallon for gas and fuel oils and 5.4 cents per gallon for lubricating oil.

The following table shows the amount of Canadian oils and naphtha inspected, together with the amount of crude that is assumed as the equivalent of the refined oils and the ratio of crude to refined:

Canadian oils and naphtha inspected, and corresponding quantities of crude oil.

Fiscal year.	Refined oils inspected.	Crude equivalent calculated.	Ratio of crude to refined.
	Gallons.	*Gallons.*	
1881	6,406,783	12,813,566	100:50
1882	5,910,787	13,134,998	100:45
1883	6,970,550	15,490,111	100:45
1884	7,656,011	19,140,027	100:40
1885	7,661,617	19,154,042	100:40
1886	8,149,472	21,445,979	100:38
1887	8,243,962	21,694,637	100:38
1888	9,545,895	25,120,776	100:38
1889	9,462,834	24,902,195	100:38
1890	10,121,210	26,634,763	100:38
1891	10,270,107	27,026,597	100:38
1892	10,370,707	27,291,334	100:38
1893	10,618,804	27,944,221	100:38
1894	11,027,082	29,018,637	100:38
1895	10,674,232	28,090,084	100:38
1896	9,666,733	25,438,770	100:38
1897	9,441,098	24,844,995	100:38

The following, taken from the Report of the Bureau of Mines, by Mr. Archibald Blue, shows the proportion of refined products obtained from the crude from 1892 to 1897, inclusive. A decided gain in the percentages is shown in the latter years.

Proportion of refined products from Canadian crude petroleum.

Product.	1892.	1893.	1894.	1895.	1896.	1897.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Illuminating oil........	38.67	39.12	41.10	43.31	45.08	42.62
Lubricating oil..........	12.35	12.45	10.91	9.51	9.07	7.67
All other oils............	27.34	28.14	30.45	28.07	31.09	35.10
Total	78.36	79.71	82.46	80.89	85.24	85.39

IMPORTS AND EXPORTS.

The Statistical Yearbook of Canada for 1897, issued by the Department of Agriculture, Ottawa, Canada, gives the following tables, showing the exports and imports of petroleum:

Exports of Canadian petroleum since 1868.

Year ending June 30—	Quantity.	Value.	Year ending June 30—	Quantity.	Value.
	Gallons.			*Gallons.*	
1868.....	46,282	$9,341	1883......	1,422	$368
1869.....	690,553	127,319	1884......	327,563	7,546
1870.....	4,748,557	966,461	1885......	954,966	27,303
1871.....	5,753,678	1,052,870	1886......	260,449	30,957
1872.....	7,897,054	1,341,099	1887......	310,667	11,151
1873.....	9,355,325	1,819,183	1888......	355,501	66,834
1874.....	1,276,641	298,417	1889......	110,470	18,681
1875.....	9,844	1,592	1890......	358,804	15,812
1876.....	14,804	3,363	1891......	436,516	18,726
1877.....	3,926,139	900,542	1892......	440,906	18,217
1878.....	73,590	9,423	1893......	178,101	6,814
1879.....	797,079	97,049	1894......	68,740	2,722
1880.....	10,611	1,059	1895......	63,543	3,572
1881.....	2,456	631	1896......	18,241	2,971
1882.....	662	136	1897......	1,831	230

The following table gives the figures of foreign imported oil since 1882, from which it will be seen that there has been a steady increase in the consumption of American oil:

Foreign oil imported into Canada since 1882.

Year ending June 30—	American oil.	Year ending June 30—	American oil.
	Gallons.		*Gallons.*
1882	3, 026, 186	1890	5, 075, 650
1883	3, 088, 414	1891	5, 321, 524
1884	3, 148, 920	1892	5, 793, 636
1885	3, 813, 379	1893	6, 249, 946
1886	3, 803, 724	1894	6, 666, 323
1887	4, 309, 397	1895	6, 752, 425
1888	4, 493, 924	1896	5, 804, 067
1889	4, 723, 698	1897	5, 665, 204

Notwithstanding the high protective duty imposed in Canada, the quantity of illuminating oil manufactured was only 42 per cent of the total consumed in 1896. The oil exported is insignificant, and probably reached points that were only supplied by rail or water from Canadian ports.

NEWFOUNDLAND.

The island of Newfoundland has also produced oil in a limited way. The indications are said to extend over an area of 250 square miles. The newer Carboniferous rocks, with their shales, limestones, and conglomerates, are closely associated with the very much older Laurentian rocks. Test wells that have yielded an oil of good quality have been drilled by the Newfoundland Oil Company in the Lower Carboniferous rocks 6 to 8 miles from the sea. The gravity of the oil is 35° Baumé, and contains the following: Naphtha, 7 per cent; illuminating oil, 56 per cent; lubricating oil, 34 per cent; coke, 3 per cent. The quality of both the illuminating and the lubricating oil is good.

Mr. Boverton Redwood, well known as a petroleum expert, says that on the west coast of Newfoundland several productive wells have been drilled, and it seems probable that this might become an important oil district. The oil-bearing formation is considered to extend over an area of about 250 square miles, lying on the west coast. The Newfoundland Oil Company has a concession of 14 square miles of territory surrounding Parsons Pond, about 30 miles north of Bonne Bay. On this property wells have been drilled to a depth of over 1,000 feet, and one of them is said to have yielded, when the oil was first struck, 15 barrels in seventy minutes. Mr. Howley says that there are three different oil-bearing strata at depths of 700, 1,040, and 1,230 feet, respectively, and he thinks that the oil is not confined to small isolated reservoirs but is generally distributed throughout the shale, which would give rise to a slower accumulation but one of a more permanent character.

PERU.

There were three companies operating in Peru in 1897. The London Pacific, operated by British capital, has been for a number of years in litigation with Dr. W. O. Tweddle, formerly of Franklin, Pennsylvania, which has delayed operations so that only in the latter half of 1897 were its works operated. Its production comes from Negritos, about 45 miles north of Payta and 6½ miles east of the shipping port of Talara. There have been 45 wells drilled at this place, and several years ago there was a production amounting to 1,000 barrels a day. The wells are from 500 to 700 feet in depth, but lack staying qualities. The color of the oil is dark, and the gravity ranges from 28° to 34° Baumé. A pipe line 6½ miles long connects these wells with a receiving tank on the beach at Talara. The illuminating oil made from this crude is of an inferior quality, producing a smoky flame, with a slight deposit of soot. About 120 miles north of Negritos, at Zorritos, 20 miles south of Tumbes, Mr. Faustino G. Piaggio has been producing petroleum for a number of years. There have been about 100 wells sunk at this locality, all of which gave more or less petroleum when first drilled, but at present there are only 20, producing about 10,000 gallons, or 240 barrels, a day. A refinery at this point supplies this section by vessels for miles along the coast.

The property of the French company is situated near Tumbes, not far from the operations of Mr. Piaggio. A number of wells have been sunk, and their production is about 90 barrels a day. They commenced in 1897. In a letter from Mr. H. Tweddle, of New York, it is stated that the French company already referred to has drilled a dozen or more wells, most of which are only small producers. As yet the company has not entered the active market, although it has had a tank steamer on the coast for the last two years. Mr. Piaggio, who is working close to the French company, is increasing his output. The English company working at Talara has drilled several more wells, and is running its tank steamer, called the *Bakuin*, between this port and Callao, and supplying both crude and fuel oils, and kerosene, to the native markets.

No exporting of any kind has been done. It is reported that one or two new companies will begin operations, but they have not yet begun.

The following statement of the production of petroleum in the Zorritos oil field of Peru has been furnished by Mr. Faustino G. Piaggio, who is operating in that field:

Production of petroleum in Zorritos oil field of Peru in years 1896 and 1897.

Year.	Crude petroleum.	Refined.	Lubricating oil.	Benzine.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*
1896	1,996,520	608,900	896,450	4,650
1897	2,874,980	959,645	964,680	7,940

The illuminating oil exported from the United States to Peru in 1897 was 580,850 gallons.

BARBADOS AND TRINIDAD.

The following interesting account of the production of petroleum, Barbados tar, and fluid and solid bitumen in these islands of the West India group is taken from an article by Mr. Boverton Redwood, of London, published in 1897:

> In the British West Indies petroleum occurs in Barbados and Trinidad. Under the name of Barbados tar, the crude oil found in the former island occupied at one time a place in the materia medica of this and other countries. It was obtained from dug wells in the Scotland district, which included the parishes of St. Joseph and St. Andrew. The wells, which were known as Lloyd's wells, were about 5 feet in diameter and from 80 to 100 feet in depth, and were lined with pine wood. The daily yield of oil was said to be from 1 to 2 barrels per well. At one time Lloyd's wells numbered 21, but there are now only 5. Drilling is now being carried on in this district, and the results are awaited with considerable interest. The Pitch Lake of Trinidad, the most important deposit of solid or semisolid bitumen known, is usually visited by travelers in the West Indies. It has an area of about 110 or 112 acres, and the uneven surface has been compared to the back of a turtle. The projections consisted of spherical, polygonal, and mushroomlike masses, which vary from 30 to 200 feet in diameter and are said to be each subject to a motion of its own, whereby the lower portions are brought up and rolled over from the center toward the edges. As the depressions between these separate masses are constantly filled with water, the bitumen is prevented from coalescing. The pitch, or asphalt, is worked with picks to a depth of a foot or two, and the excavations soon become filled up with fresh plastic material rising from below and hardening. Ordinarily the surface is sufficiently firm to bear the weight of horses and carts. The softer portions of the lake constantly evolve gas, which is stated to consist largely of carbon dioxide and sulphureted hydrogen, and the pitch, which is always found honeycombed with gas cavities, continues to exhibit this action for some time after its removal from the lake. The depth of the deposit is not known, and it has been found that in pits dug some little distance from the edge of the lake the flow of bitumen from the bottom is so great that a depth of 12 feet can not be exceeded. Much doubt exists as to the origin or source of the material. Fluid bitumen is seen to ooze from the bottom of the sea on both sides of the island of Trinidad, and to rise to the surface of the water. It was stated that about a century ago a plat of land on the western side of Trinidad, nearly halfway between the capital and an Indian village, sank suddenly, and was immediately replaced by a small lake of pitch. In this manner the Great Pitch Lake was probably formed. Very large quantities of the pitch are exported for paving and other purposes, the shipments amounting to about 100,000 tons a year. A circular line of tramway has been constructed on the lake to facilitate the removal of the asphalt, and the material excavated near that line is transported direct to the vessel which is being loaded. The asphalt from other parts of the deposit is dug up in large pieces and removed in carts to the beach, where it is put into lighters, and thus transferred to the ship.

ARGENTINA.

Petroleum is found in the division of Mendoza, not far from the town of Mendoza, on the east slope of the Andes Mountains. It is used principally for fuel upon the railroad.

MEXICO.

There is also some production in Mexico, about 40 miles inland from Vera Cruz, where there are 10 wells producing from 10 to 50 barrels a day each. This oil is very dark and heavy.

RUSSIA.[1]

The gross production of crude petroleum in Russia, at Baku, was 54,744,303 barrels in 1897 as compared with 49,633,252 barrels in 1896. The gross increase was 5,110,151 barrels as compared with an increase of 1,919,269 barrels for 1896 over 1895. This is a gain of 10.3 per cent. To this production must be added that of the other fields, the most prominent of which are Grosni and Ilskaja, estimated to be 2,350,000 barrels, making in round numbers 57,100,000 barrels as compared with 60,568,081 barrels of petroleum produced in the United States in 1897, so that Russia's gross production was only 3,468,000 barrels less than that of the United States.

Owing to the imperfect methods of storing the crude petroleum, in open pits or reservoirs, the loss by evaporation and absorption is very great. This, together with what is used for fuel, amounts to from 7 to 8 per cent. The amount that reaches the still of the refiner, and is known as "profitable production," aggregated 51,645,568 barrels, equal to an average daily production of 141,500 barrels.

It must be remembered, however, that this comparison of crude petroleum produced in Russia with that produced in the United States is misleading, as the proportion of merchantable products is much less than is secured from the average petroleum produced in the United States.

The illuminating oil secured from the gross amount only represents 26 to 30 per cent, whereas that of the United States will give a general average of 65 to 70 per cent of illuminating oil. Besides, the proportion of benzine in Russian oil amounts to but 3 to 4 per cent as compared with 12 to 15 per cent in the petroleum of the United States. The proportion of lubricating oil is about 3 per cent as compared with 8 per cent in the United States. Thus, one barrel of crude petroleum in the United States represents about 90 per cent of marketable products, while only about 33 to 36 per cent is obtained from one barrel of Russian crude petroleum. These proportions are, in a small measure, offset by the value of the large percentage of residuum obtained from the Russian petroleum, which has of late years commanded a much higher price as a fuel, being close to the value of crude petroleum.

The profitable petroleum—by which is meant the petroleum collected in tanks and reservoirs, a portion being absorbed by the ground and a large amount being consumed for fuel—produced in Baku in 1897 was, as before mentioned, 51,645,568 barrels, valued at 7½ copecks per pood. As a copeck is worth 0.582 cent, the value is equal to 4.36 cents per pood, and as there are 8.18 poods in a barrel the result is 35½ cents per barrel as the average value of crude petroleum in the reservoirs at Baku. The value of the total Russian production would be $18,334,176, while that of the 60,568,081 barrels produced in the United States in 1897 was $40,929,611, equal to 67.6 cents per barrel.

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[1] The writer acknowledges indebtedness for many translations and other information secured from the American Manufacturer and Iron World, of Pittsburg, Pennsylvania, and to Miss Belle Hill, for her knowledge and ability in collecting statistics for this and the Natural Gas Report.

It is remarkable that almost the entire Russian production at Baku comes from a small area of not over 8 square miles. There are four districts that produce all the oil at Baku, namely, Balakhany, Romany, and Saboontchy—which have an area of 4 square miles of a level plateau 175 feet above the level of the Caspian Sea (which is 83.6 feet below the level of mean tide of the ocean), and 8 miles northeast of the town of Baku—and Bibi Eibat, which lies 2 miles to the south on the seashore. These fields are connected by numerous pipe lines with Blacktown, a suburb of Baku, where the refineries are located. The remarkable production of these four pools of small area is without precedent, as the production from 1859 to and including 1897 is the enormous total of 628,000,000 barrels of crude petroleum. The total production of crude petroleum in the United States for the same period was 831,150,595 barrels. The production from the flowing wells is decreasing and that from pumping wells is increasing. In 1896 22½ per cent of the production was from flowing wells; the proportion for 1897 is estimated to be 21 per cent of the total output. The depth is also increasing. The following is taken from the report of Mr. James C. Chambers, United States consul at Batoum, and refers to prospective work:

> So far all efforts to find new fields in the vicinity of Baku have been unsuccessful. At Hindar-Zinda, about 50 miles north of Baku, on the shore of the Caspian, three wells were started in 1896, having been located upon surface indications which were remarkably good. At the end of 1897 these wells had all been drilled deeper than 1,000 feet, without finding oil in paying quantities, and, although they are not yet abandoned, I think no one expects any good results from them. Still farther north, between Derbent and Petrovsk, other wells have been drilled, and while a good prospect of oil was found at shallow depth, deeper drilling proved them practically failures. South of Baku, about 15 miles from Poota, a well was drilled more than a year ago, but was then stopped. Recently drilling has been recommenced upon this well, and when I last heard from it they were nearly 1,200 feet deep, with no oil. Almost every week the Tiflis newspapers report test drilling at some place or another in the Caucasus, but as they never report any successes from such drilling I presume it is always a failure.

In the last quarter of 1897 another large conflagration occurred in the Baku field. The cause of the conflagration is not known. Four large wells or fountains, producing 38,000 barrels of crude petroleum daily, caught fire. Before the fire burned itself out 29 rigs and 300,000 barrels of crude oil, which was stored in pits near by, were consumed.

In the Grosni field, on the northeast slope of the Caucasus Mountains, and about 300 miles northwest of Baku, there are numerous oil springs, as well as several hot springs. There has been considerable activity in this field for the past five years, and a number of wells are now drilling, and several large basins and reservoirs connected by pipe lines have been constructed. The oil is heavy, ranging from 88° to 95°, but is not of the quality that will produce illuminating and lubricating oils in quantity to justify refining, and most of it is sold for fuel purposes A number of spouting wells have been developed that have produced largely for the first few weeks and have afterwards settled down to moderate wells. They are from 350 to 800 feet in depth.

The total production for 1897 has been figured at 1,800,000 to 2,000,000 barrels. That such a vast amount of crude petroleum as is produced in Russia, especially in the Baku field (which produces 96 per cent of the total output), does not shut out the American petroleum to a much greater extent in Europe is at first surprising, especially when it is considered that the Baku oil comes from a small area closely connected, and that a considerable portion of it is from flowing wells located on the shores of a large inland sea and connected by thousands of miles of river and railroad systems of transportation. The outlet to Europe from Baku is over the Transcaucasian railroad to Batoum, on the Black Sea, a distance of 575 miles. This railroad crosses the Caucasus Mountains at an elevation of 3,000 feet above the sea, and the grades are very heavy. In the United States the production averages 450 to 500 miles from the seaboard, and it is gathered over about 18,000 square miles of area, yet the exports alone of refined or illuminating petroleum from the United States in 1897 were 18,365,500 barrels, as compared with 11,042,000 barrels of illuminating petroleum shipped from Baku, of which 5,920,230 barrels were shipped from the seaport town of Batoum, the greater part going to countries in Europe and competing with that from the United States. The remaining 5,000,000 barrels, in round numbers, were marketed in the cities of Russia, a small portion reaching the eastern part of Germany, being distributed by the inland system of river and railroad transportation.

The main reasons assigned for the conditions of the trade as above mentioned are as follows:

First. There is a much smaller percentage of refined or illuminating petroleum obtained from Russian crude than from that of the United States. As compared with the petroleum produced in the United States, the amount will not vary much from one-half, while the other products in the oil found in the United States are more valuable than the Russian.

Second. The railroad connecting Baku and Batoum crosses the Caucasus Mountains at high elevations, with steep grades. To increase the capacity of the railroad, a system of pipe lines reaching over this summit was laid several years ago. It was poorly constructed and equipped. The gravity of the crude oil, together with the low temperature of the summit of the mountains crossed, greatly reduces the availability of the pipe line for transporting oil. The railroad has suffered several interruptions by floods.

Third. The transportation by means of the Caspian Sea and the Volga River and its tributaries involves many transfers of bulk from larger or smaller vessels. On the rivers transportation is closed by ice four or five months of the year. This requires an immense storage capacity at the terminals and a large amount of idle capital.

Fourth. The quality of the Russian illuminating petroleum is generally inferior to that exported by the United States.

Some of these natural difficulties are being overcome. The building of a pipe line connecting Baku and Batoum, properly constructed and equipped, will reduce transportation expenses and make this field a much more formidable rival for the trade of Europe than it has been in the past. The Russian Government has given a contract to an iron works at Mariopol, on the Sea of Azof, for manufacturing 8-inch wrought-iron pipe, and it is reported that the iron company has succeeded in manufacturing a good quality of pipe, which is to be laid first from Batoum to Michaelova, 145 miles east of the former. The line is to be completed by sections until Baku is connected, following the railroad. The introduction of residuum as a fuel, both in the region reached by the Volga and its tributaries, as well as on the Black Sea has caused a large increase in the sale of this article, and has enabled the refineries to quote the prices of the other products at reduced figures and to improve the quality of the lighter products, as a smaller per cent is extracted from the crude. The residuum is used almost entirely for fuel on vessels on the Caspian Sea and by the railroads whose systems connect with it. It is finding its way into manufactories throughout the interior of Russia where it can be reached by water transportation, and where other fuel is expensive.

The following is taken from the very able and elaborate report of the United States consul, James C. Chambers, of Batoum:

> The statistics annexed will give a fair idea of the progress made by the Russian petroleum business in the past year, showing that it was an active one for the trade; owing, however, to the low prices for refined which ruled during the whole period, and especially the last half, the financial results were undoubtedly much less satisfactory than in 1896. If the price of refined was unsatisfactory, the trade was in a great measure compensated by the good prices for residuum and crude, which continued steady and high throughout the year, advancing after the closing of Volga navigation, an almost unprecedented occurrence, as residuum bought after the close of navigation is held for the next season's navigation, a period of usually five months; and, notwithstanding the heavy crude production and the fact that during the winter months the greatest outlet for petroleum products is practically closed, the prices of both residuum and crude in December were the highest of the year.
>
> It is difficult, if not impossible, to ascertain the average cost of producing oil at Baku; but the highest estimate I have heard was 4 copecks per pood (17 cents per

barrel of 42 gallons), and I believe that that cost is rarely exceeded, while many producers who are fortunate in getting large flowing wells can undoubtedly produce oil at a much lower figure. These producers must have had a very profitable year, as the price up to the close of navigation was never less than 7½ copecks per pood (about 32 cents per barrel), and the last month in the year it reached about 42 cents per barrel.

The remarkable increase in the demand for residuum for fuel in Russia, and the consequent high prices which ruled throughout the year for that product, coupled with the low price of illuminating oil, resulted in making fuel oil the main object of the refining and relegated refined to second place. The average price of residuum in 1897 was the highest ever known in the trade, notwithstanding the production of residuum exceeded that of any previous year by about 25 per cent. I am not able to give the average price of the year accurately at present, but it was never for any length of time below 34 cents per barrel, and was often higher, closing with the year at over 40 cents per barrel. The increase in the demand was due principally to increased distributing facilities in the manufacturing districts of Russia, but there is no doubt that it was also partly due to an increase in the manufacturing industries of the Empire. It is not many years since it was the opinion of some of those engaged in the fuel-oil trade, and therefore most competent to judge, that the price of residuum at Baku could not go above 6 copecks per pood (25 cents per barrel) without curtailing the demand; but either they were wrong or the manufacturing industries of Russia have increased more rapidly than was anticipated, for in 1897, with the average price at least 10 cents per barrel above that figure, the demand increased 25 per cent, and an expression of opinion regarding the future at this time would be very hazardous. At present, three or four weeks before shipments via Volga can commence, because of navigation being closed by ice, residuum is selling at about 42 cents per barrel, and there seems to be no fear on the part of buyers that prices will not be maintained, notwithstanding the present immense crude production.

Prices of refined oil were very low at the close of 1896, but not so low as to make export entirely unprofitable. They continued declining throughout the year, however, and by midsummer were below the actual cost of the oil, based upon prices quoted for crude and residuum, but the high price of residuum and the fact that probably 70 per cent of the refined was produced by refiners who had their own crude, prevented any great falling off in export.

To explain the influence of the combination of crude producing and refining, I give the following customary method of calculating the cost of refined, based upon 3½ poods of crude being necessary for the production of 1 pood of refined and 2 poods of residuum:

	Copecks.		Cents.
3.5 poods (126.4 pounds) crude at 7½ copecks (3¾ cents per pood (36.112 pounds)	26.25	=	13.12
Plus cost of labor, chemicals, etc	4	=	2
Total	30.25	=	15.12
Less value of 2 poods (72 pounds) residuum at 8 copecks (4 cents)	16	=	8
Cost of 1 pood (36.112 pounds) refined	14.25	=	7.12

which is equivalent to about 1¼ cents per gallon, while the average price realized the last half of the year was certainly not more than 12 copecks per pood (6 cents per 36.112 pounds), and probably even less. But, as probably 70 per cent of the refined exported was manufactured by refiners who had their own production, the market price of crude played no very important rôle in the export, as the cost of producing crude oil, as before stated, is rarely greater than 4 copecks per pood (2 cents per 36.112 pounds), while I believe it averages even lower. However, taking

4 copecks as a basis of cost of crude to the refiner, who has his own production, the following may be given as the cost of refined oil to such refiners:

	Copecks.	Cents.
3.5 poods (126.4 pounds) crude at 4 copecks per pood (2 cents per 36.112 pounds)	14 =	7
Labor, chemicals, etc	4 =	2
Total	18 =	9
Less 2 poods (72 pounds) residuum at 8 copecks per pood (4 cents per 36.112 pounds)	16 =	8
Cost of a pood refined	2 =	1

Consequently, I believe that there was little or no loss in the export of refined; and, as some refiners had more crude than they could use, which cost them much less than 4 copecks per pood, because of wells flowing largely, the average result was even better than shown above.

Of course, the high price of crude and low price of refined made it out of the question for many refiners to do business; and, while much more than half the total refining capacity was worked during the year, I believe at least half of the refineries were shut down.

The combination of refiners, which was organized in April, 1895, and was known as the "Union," was dissolved in October, 1897. The agreement was for two and a half years, to be extended two and a half years more with the consent of all concerned; but, as practically all of those interested (except those instrumental in organizing the union, who had great advantages over the majority) declined to renew their agreement, the union passed out of existence on October 13. The first year of this combination was very profitable; not, however, because of the trade being unified (that not being the case, as 20 to 25 per cent declined to go into the combination), but because of the remarkable advance of refined prices in the United States. There is little doubt, however, that the rank and file of the Baku refiners were led to believe that the advance in prices was wholly due to the existence of the union, and that that organization was in a position, or would soon be in a position to dominate prices throughout the world by coming to terms with the American trade. But the promised agreement with the Americans did not materialize, and prices at Baku and Batoum had to follow American prices down the scale, as they had followed them up; and by the end of 1896 the decline was considerable and still continued, and the trade commenced to realize that someone had made a mistake. With declining prices came disagreements among the agents of the union and their representatives in Europe, as this combination did not have a single head, but had three selling agents who had representatives in the different European markets, and who could not sell a gallon of refined without the permission of a committee of fourteen, which met semiweekly at Baku, and usually took three or four weeks to deliberate over the selling of one cargo. With an advancing market, as in 1895, this deliberation proved profitable, as the greater delay the higher the price; but with declining prices it worked quite differently, for by the time the committee had made up its mind to sell, the buyer had either withdrawn or dropped his bid. Under the circumstances it was not surprising that the business fell off, especially as during the summer so many members of the committee were away that it was always difficult and sometimes impossible to obtain a quorum.

It may be realized that this sort of business was profitable to those who were not in the union, but were its competitors, as they (principally case exporters at Batoum) managed to sell a great deal of case oil, forestalling the union; and, as they bought their refined upon the basis of sales, they undoubtedly reaped a fine harvest, even on the declining market.

As the state of affairs was gradually realized by the smaller refiners in the union, who had no other interest than to profitably dispose of their goods and no reputation to sustain in the world's markets, the dissolution of the union was not surprising. At present. there seems absolutely no prospect of the trade coming to any agreement. I believe that it is the opinion of a majority of the refiners that combination is useless; which, however, was certainly not clearly demonstrated by the attempt of which I have been writing, as that failure was due entirely to mismanagement.

Railroad freight rates.—The export of refined oil was apparently so unprofitable that the usual childish cry to the Government for assistance was sent up early in 1897 in the shape of petitions for a reduction of railway freights to Batoum; but as that plan had been tried once by reducing the freight on refined for export from 19 copecks per pood (about 2 cents per gallon) to 9 copecks per pood (about nine-tenths of a cent per gallon) and had signally failed in accomplishing its object (which was to drive American oil out of the foreign markets, but which resulted only in further loss to exporters, because of the reduction being met promptly by the Americans, and in a big loss of revenue by the railroad, said to have amounted to about $4,000,000 before the old rate was restored), it seemed very improbable that the Government would again try that method. However, in November the trade was notified that the freight rate would be reduced to 12 copecks per pood on refined oil for export, commencing December 15, and that rate, which is equivalent to about 1¼ cents per gallon, has been in force since that date, but apparently has not resulted in materially increasing exports. That it will increase the profits of the refiner who exports refined made from crude which he produces himself can not be doubted; but that it will help the refiner who buys his crude is not at all apparent, for present prices abroad are too low to justify refiners paying 9 to 10 copecks per pood (4½ to 5 cents per 36 112 pounds) for crude. The refiner who produces his own crude—and I find that the statistics of 1897 show that 65 to 70 per cent of the total crude was produced by refiners—can now undersell all others in the foreign markets without the least sacrifice, as, upon a basis of 4 copecks per pood (2 cents per 36.112 pounds) as cost, with the existing price of residuum and the reduced freight rate, such refiners can, without loss, sell refined oil at from 1.6 to 1.8 cents per gallon free on board Batoum (equivalent to about one-half cent per gallon at Baku), which is more than 1 cent per gallon lower than the prices of the last year.

Increasing cost of Russian oil production.—In the Baku oil district the steadily increasing depth of the wells has greatly increased their cost. In parts of the oldest territory (Balakhani), paying wells are still struck at from 500 to 700 feet, and as much drilling has recently been done in this old territory, the average depth of wells completed is not so great as it would be without such shallow wells. In Saboontchy the oil is not found much under 1,100 to 1,400 feet, while in Romany and Bibi Eibat, the wells are now over 1,400 feet, one good well in the former territory being 1,743 feet, which is now flowing over 12,000 barrels per day. Of course, the cost of wells varies according to their depth, but statistics from an average well at Saboontchy will give a fair idea of the average cost of wells. Owing to the formation being devoid of rocks and wholly sandy, it is necessary to pipe the hole as fast as drilled, and as much difficulty is found in getting pipe in the hole, wells are commenced with very large holes, varying according to the depth it is expected to drill. For wells which are expected to be over 1,000 feet the hole at the start is usually 26 inches in diameter, and is finished with from 14 to 16 inch pipe, according to the success met with in drilling. The pipe used is not the cast-iron or lap-welded pipe used in the United States, but is made of three-sixteenth to one-fourth inch iron and riveted, the joints being about 4 feet each clear of the coupling, which is riveted on the pipe. The well was started with 26-inch pipe, of which 175 feet were used; then came 313 feet of 24-inch, 455 feet of 22-inch, 735 feet of 20-inch, 1,025 feet of 18-inch, and the well was finished with 1,148 feet of 16-inch pipe. The total cost of the well was about 35,320 rubles, equivalent to about $18,619. But this is not the whole cost of the well ready to pump or flow, as it generally takes the work of weeks, and sometimes months, to get the well cleaned out after drilling is finished, as they usually contain much sand and often mud and water, so that it is safe to estimate the average cost of wells in the Baku territories at $20,000 each.

PRODUCTION.

The total production of crude petroleum in the Apsheron Peninsula and the shipments of the chief petroleum products from Baku from 1880 to 1897 have been as follows:

Total production of crude petroleum on the Apsheron Peninsula and shipments of petroleum products from Baku from 1880 to 1897.

[Barrels.]

Year.	Production.	Shipments from Baku.					
		Illuminating.	Lubricating.	Other products.	Residuum.	Crude oil.	Total.
1880......	3,055,247	976,933	....	....	867,416		1,844,349
1881......	4,889,640	1,564,337	....	....	1,136,228		2,700,565
1882......	6,111,740	1,650,207	87,335	....	2,200,276		3,887,818
1883......	7,333,838	1,838,149	139,384	....	2,297,347		4,269,880
1884......	11,002,624	2,689,365	182,941	....	3,569,226	....	6,441,532
1885......	14,179,838	3,666,297	195,886	....	4,144,185		8,005,868
1886......	18,336,463	4,278,591	207,831	....	4,424,198		8,910,620
1887......	20,170,856	5,378,729	281,257	....	5,072,582		10,732,568
1888......	23,471,270	6,111,739	317,348	....	7,150,897		13,579,984
1889......	25,060,496	7,469,438	415,648	....	10,831,296	550,122	19,266,504
1890......	29,217,126	8,227,384	562,347	....	11,858,191	855,745	21,503,667
1891......	35,206,905	9,046,454	623,472	....	12,640,386	1,454,969	23,765,281
1892......	36,430,248	9,608,801	696,821	....	14,254,280	1,466,993	26,026,895
1893......	41,198,085	10,501,222	709,046	....	17,542,787	1,577,018	30,330,078
1894......	37,811,773	8,704,156	782,396	....	23,667,482	2,102,690	35,256,724
1895......	47,713,983	9,898,288	825,489	130,465	22,050,232	1,849,780	34,754,254
1896......	49,633,252	10,569,670	1,084,095	123,753	22,616.271	3,117,898	37,511,687
1897......	54,744,303	11,042,054	1,114,180	144,988	27,106,357	2,896,333	42,303,912

The above table gives the production and shipments of refined products and residuum from Baku. A part of the refined products and the residuum goes to inland ports by way of the Caspian Sea and the Volga River. The larger portion is shipped by rail to Batoum, on the Black Sea, and from there distributed. Attention is called to the sudden increase in the shipments of residuum, amounting to one-half of the production of crude. The average price of illuminating petroleum free on board at Batoum is quoted at from 25 to 27 copecks per pood, equal to $1.20 to $1.30 per barrel (8.18 poods = 1 barrel; 36.112 pounds = 1 pood; 0.582 cents = 1 copeck.)

The "profitable production" for the last ten years is shown in the following table:

"Profitable production" of crude petroleum in the Apsheron Peninsula from 1888 to 1897.

[Barrels of 42 gallons.]

Year.	Production.	Year.	Production.
1888	22,249,389	1893	39,703,304
1889	23,502,163	1894	36,375,428
1890	27,660,953	1895	46,140,174
1891	33,565,819	1896	47,220,633
1892	35,026,144	1897	51,645,568

The divisions of this profitable production among the four subfields on the Apsheron Peninsula are as follows:

"Profitable production" of the several fields of the Apsheron Peninsula from 1889 to 1897.

[Barrels.]

Year.	Balakhany.	Sabooutchy.	Romany.	Bibi-Eibat.	Total.
1889	8,424,364	12,905,012	....	2,172,787	23,502,163
1890	7,742,995	17,525,134	189,022	2,203,802	27,660,953
1891	9,067,861	19,992,359	1,585,342	2,920,257	33,565,819
1892	7,025,973	18,916,516	5,017,286	4,066,369	35,026,144
1893	7,070,101	17,883,692	8,943,313	5,806,198	39,703,304
1894	7,217,054	17,485,232	7,542,922	4,130,220	36,375,428
1895	8,258,961	18,500,196	13,619,639	5,761,378	46,140,174
1896	10,470,315	18,664,322	9,546,250	8,539,746	47,220,633
1897	11,774,479	20,406,918	11,821,815	7,642,356	51,645,568

WELLS AND THEIR PRODUCTION.

There are two classes of wells producing oil: Flowing and bucketing. By bucketing it is understood that, owing to the loose sand that continually comes into the well with the oil, the American system of pumping, with rods, cups, and working barrel, is impracticable, as the sharp sand soon cuts the cups. The substitute is a long pipe or bailer that goes inside of the casing, with a valve in the bottom, and connected to a small wire rope passing over the crown pulley. This rope is also connected with a drum driven by power. The bailer is hoisted to the surface, where the valve is opened automatically and the oil and water are discharged in a trough leading to a reservoir. The bailer is then allowed to descend, to be filled again.

Flowing wells are the well-known Baku fountains, some of which have given, and continue to give, say, 100,000 poods per day, or about 10,000 barrels; several of these fountains are credited with producing 60,000 barrels per day.

The production of crude petroleum from pumping (bucketing) and flowing wells for the last ten years has been as follows:

Production of crude oil from pumping and flowing wells in Baku from 1888 to 1897.

[Barrels.]

Year.	Pumping.	Flowing.
1888	13, 325, 184	8, 924, 205
1889	18, 300, 733	5, 201, 430
1890	21, 589, 242	6, 071, 711
1891	28, 777, 506	4, 788, 313
1892	25, 765, 482	9, 260, 662
1893	26, 352, 714	13, 350, 590
1894	28, 814, 428	7, 561, 000
1895	32, 350, 809	13, 789, 365
1896	36, 586, 526	10, 634, 107
1897	40, 784, 321	10, 861, 247

The profitable production from pumping and flowing wells for years 1892 to 1896 is given in the following table, by fields:

Production of crude petroleum from pumping wells, 1892 to 1896.

[Barrels of 42 gallons.]

Year.	Balakhany.	Sabooutchy.	Romany.	Bibi-Eibat.	Total.
1892	7, 025, 973	14, 234, 073	2, 558, 238	1, 947, 198	25, 765, 482
1893	7, 041, 496	14, 465, 119	3, 560, 680	1, 285, 419	26, 352, 714
1894	7, 217, 054	16, 245, 868	4, 221, 278	1, 130, 228	28, 814, 428
1895	8, 258, 961	16, 227, 824	5, 254, 480	2, 609, 544	32, 350, 809
1896	10, 452, 222	16, 938, 528	7, 021, 311	2, 174, 465	36, 586, 526

Production of crude petroleum from flowing wells, 1892 to 1896.

[Barrels of 42 gallons.]

Year.	Balakhany.	Sabooutchy.	Romany.	Bibi-Eibat.	Total.
1892		4, 682, 443	2, 459, 048	2, 119, 171	9, 260, 662
1893	28, 605	3, 418, 573	5, 382, 633	4, 520, 779	13, 350, 590
1894		1, 239, 364	3, 321, 644	2, 999, 992	7, 561, 000
1895		2, 272, 372	8, 365, 159	3, 151, 834	13, 789, 365
1896	18, 093	1, 725, 794	2, 524, 939	6, 365, 281	10, 634, 107

The greatest number of wells that produced crude petroleum at any time during the years named was as follows:

Number of producing wells on the Apsheron Peninsula from 1888 to 1897.

Year.	Wells.	Year.	Wells.
1888	239	1893	458
1889	278	1894	532
1890	356	1895	604
1891	458	1896	734
1892	448	1897	917

The statement of the number of producing wells from 1893 to 1897, by months, is as follows:

Number of producing wells in Baku from 1893 to 1897, by months.

Month.	Number of wells.				
	1893.	1894.	1895.	1896.	1897.
January	322	322	434	501	599
February	326	337	434	508	598
March	332	347	437	511	614
April	323	355	455	536	626
May	325	366	451	540	643
June	310	369	450	547	658
July	307	373	460	566	668
August	294	400	475	575	677
September	298	413	496	597	688
October	310	420	497	606	713
November	316	425	504	614	697
December	322	440	500	620	702
Total	458	532	604	734	917

The above table gives the average number of wells in operation during each month. The total represents the greatest number of wells operated during the year in Baku.

The number of wells drilling during each month from 1892 to 1897, and the number worked upon during the years 1895 to 1897, are given in the following tables:

Number of wells drilling in Baku from 1892 to 1897, by months.

Month.	1892.	1893.	1894.	1895.	1896.	1897.
January	141	62	59	80	137	226
February	131	57	60	86	141	209
March	127	69	62	86	145	222
April	117	64	72	78	150	218
May	94	69	81	86	152	227
June	84	73	79	89	159	236
July	44	69	75	100	152	250
August	45	64	73	109	152	273
September	52	58	73	116	164	279
October	45	59	69	122	194	287
November	50	58	71	133	200	291
December	58	59	75	142	208	281
Total	200	175	204	270	387	544

The year 1897, as shown in the above table, indicates great activity in the field work at Baku.

Number of wells completed in Baku in 1895, 1896, and 1897.

Month.	1895.	1896.	1897.
January	5	13	14
February	8	11	6
March	7	7	11
April	10	8	18
May	6	6	25
June	5	14	25
July	9	11	18
August	11	10	20
September	8	16	12
October	8	16	22
November	6	10	16
December	11	11	17
Total	94	133	204

The following table shows the average daily production of crude petroleum in the Baku field in 1896 and 1897, taken from the consular report of Mr. James C. Chambers. The average daily production for the United States in 1897 was 158,803 barrels, as compared with 138,897 barrels in the Baku field:

Average daily production of Baku fields in 1896 and 1897.

[Barrels of 42 gallons.]

Month.	Flowing wells.		Pumping wells.		Total.	
	1896.	1897.	1896.	1897.	1896.	1897.
January	25, 711	46, 070	88, 231	102, 350	113, 942	148, 420
February	35, 015	60, 621	91, 104	97, 682	126, 119	158, 303
March	7, 842	25, 793	90, 696	102, 324	98, 538	128, 117
April	22, 824	28, 985	95, 787	109, 556	118, 611	138, 541
May	27, 708	21, 670	100, 101	108, 504	127, 809	130, 174
June	33, 212	31, 535	92, 106	110, 714	125, 318	142, 249
July	53, 892	20, 020	97, 435	110, 016	151, 327	130, 036
August	45, 983	10, 509	103, 296	113, 145	149, 279	123, 654
September	16, 768	18, 500	109, 346	114, 858	126, 114	133, 358
October	20, 024	12, 929	101, 715	121, 873	121, 739	134, 802
November	19, 628	52, 700	101, 684	118, 680	121, 312	171, 380
December	33, 856	21, 472	105, 250	108, 959	139, 106	130, 431
General average	28, 539	28, 935	98, 062	109, 962	126, 601	138, 897

In the following table is given a statement of the greatest number of wells drilling at any time during each of the years from 1889 to 1897, together with the total number of wells drilled deeper, and the total length, in sagenes, of all wells drilled:

Total number of wells drilling, number of wells drilled deeper, and length of wells drilled in Baku from 1889 to 1897.

Year.	Total number of wells drilling.	Total number of wells drilled deeper.	Total length, in sagenes, of wells drilled.
1889	121	28	6, 500
1890	231	50	14, 810
1891	292	87	19, 980
1892	200	111	11, 670
1893	175	103	10, 980
1894	204	101	12. 859
1895	270	131	20, 864
1896	387	172	28, 126
1897	544	225	39, 847

1 sagene = 7 feet.

SHIPMENTS FROM BAKU AND FROM BATOUM.

The following table contains the shipments of petroleum and its products from Baku, by months during 1897, and the total shipments for 1896, in thousand gallons of the United States standard, taken from the consular report of Mr. James C. Chambers, of Batoum:

Output of all products from Baku in 1897.

[In thousand gallons.]

Month.	Illuminating.	Lubricating.	Residuum.	Crude.	Other products.	Total.
January ...	30, 720	3, 795	4, 305	1, 845	15	40, 680
February ..	26, 405	3, 015	9, 585	3, 160	35	42, 200
March	44, 335	3, 135	82, 870	14, 570	265	145, 175
April	46, 970	3, 380	132, 060	18, 340	335	201, 085
May	48, 155	4, 830	156, 015	14, 380	70	223, 450
June	45, 530	4, 405	153, 490	14, 775	670	218, 870
July	43, 095	4, 190	157, 600	16, 125	95	221, 105
August.....	46, 510	3, 870	175, 790	23, 265	555	249, 990
September .	38, 540	3, 080	139, 275	10, 270	600	191, 765
October	44, 295	5, 060	106, 295	7, 975	765	164, 390
November..	25, 265	6, 950	3, 500	2, 190	370	38, 275
December ..	18, 215	150	6, 315	3, 150	2, 150	29, 980
Total ..	458, 035	45, 860	1, 127, 100	130, 045	5, 925	1, 766, 965
1896........	404, 800	33, 740	901, 825	75, 165	5, 315	1, 420, 845

In the following table will be found the shipments of petroleum and its products from Batoum in 1896 and 1897, in United States gallons, also taken from the report of Mr. Chambers:

Shipments of petroleum products from Batoum in 1896 and 1897 (U. S. gallons).

Country to which exported.	Crude and residuum.		Lubricating.		Illuminating distillate.		Refined.		Total.	
	1896.	1897.	1896.	1897.	1896.	1897.	1896.	1807.	1896.	1897.
Austria	428,825	205,190	1,211,975	2,850,120	7,065,480	12,381,270	2,182,770	2,826,530	10,909,050	18,263,110
Belgium	70,515	3,546,595	2,306,855	8,086,275	....	233,185	4,282,835	1,879,690	6,660,205	13,745,745
Bulgaria and Servia	1,500	700	32,700	58,850	....	....	4,486,055	6,939,730	4,520,255	6,999,280
China and Cochin China	....	....	....	....	....	....	11,251,210	19,406,270	11,251,210	19,406,270
Egypt	19,800	6,750	70,700	140,600	....	....	8,458,240	11,001,690	8,548,740	11,149,040
United Kingdom	168,355	2,116,810	2,337,375	4,725,945	9,666,955	13,646,660	19.068,125	23,485,345	31,240,810	43,974,760
France	1,346,870	1,637,395	3,705,990	6,699,545	14,785,630	12,855,135	1,291,915	856,270	21,130,405	22,048,345
Germany	443,265	1,236,865	6,132,055	8,518,810	15,000	97,000	1,934,795	7,257,905	8,525,115	17,110,580
Holland	....	....	....	100,000	....	....	....	....	....	100,000
India	....	....	....	1,000	....	....	38,160,280	34,984,880	38,160,280	34,985,880
Italy	450,650	1,843,840	208,025	559,800	....	....	4,953,115	5,862,220	5,611,790	8,265,860
Japan	....	....	....	....	....	....	3,460,540	6,142,140	3,460,540	6,142,140
Java	....	....	....	....	....	....	9,749,700	1,362,250	9,749,700	1,362.250
Manila	....	....	....	....	....	....	1,525,100	1,626,000	1,525,100	1,626,000
Malta	....	....	....	....	....	....	635,495	1,674,415	635,495	1,674,415
Roumania	1,050	4,100	254,900	233,500	....	....	311,070	515,740	567,020	753,070
Spain	....	320,655	5,000	759,445	232,865	....	....	....	237,865	1,080,100
Turkey	41,950	73,450	74,350	130,700	....	....	27,881,400	33,336,825	27,997,700	33,540,475
Suez Canal (bulk)	....	....	....	....	....	....	19,208,920	56,402,320	19,208,920	56,402,320
Africa	....	....	....	....	....	....	250,250	1,140,360	250,250	1,140,360
Other countries	....	....	5,500	4,500	....	....	239,190	511,170	244,690	515,670
Total exports	2,972,780	10,992,350	16,345,425	32,869,090	31,785,930	39,213,250	159,331,005	217,210,980	210,435,140	300,285,670
Russia	377,160	255,470	895,350	1,143,555	15,850	33,700	26,384,096	31,438,865	27,672,456	32,871,590
Total shipments	3,349,940	11,247,820	17,240,775	34,012,645	31,801,780	39,246,950	185,715,101	248,649,845	238,107,596	333,157,260
Increase	....	7,897,880	....	16,771,870	....	7,445,170	....	62,934,744	....	95,049,664

NOTE.—Suez Canal bulk shipments were for points beyond the canal, but unknown here. Distillate to United Kingdom was gas oil.

The preceding table shows that there were shipped from Batoum of crude and refined petroleum and other products a total of 7,932,600 barrels in 1897, as compared with 5,669,230 barrels in 1896, being an increase of 40 per cent.

STOCKS AT BAKU.

The following table gives the stocks of crude petroleum at the wells and refineries, and the total stocks of illuminating, lubricating, and residuum at Baku at the close of 1896 and 1897, taken from the report of Mr. James C. Chambers:

Stocks of all products at Baku December 31, 1896 and 1897.

Product.	1896.	1897.
Crude:	*Barrels.*	*Barrels.*
At wells	764, 690	592, 547
At refineries	2, 636, 524	1, 840, 212
Total	3, 401, 214	2, 432, 759
	Gallons.	*Gallons.*
Illuminating oils	71, 785, 020	67, 274, 980
Lubricating oils	6, 920, 180	9, 610, 725
Residuum	238, 460, 315	263, 532, 270

AUSTRIA-HUNGARY.

GALICIA.

The production of crude petroleum declined largely in 1897. The largest falling off was in the Schodnica field, in the Drohobycz district, which increased more than double in 1896 as compared with 1895, but at this writing the full returns have not been received. It is generally conceded that deeper drilling will have to be resorted to, and this will involve additional expense. The price has also decreased. The report for 1896 for this country was very full, and little remains to be added. The shipments, which are close to production, as the tankage is limited, were 2,087,617 barrels in 1897, as compared with 2,254,366 barrels in 1896.

Shipments from, and consumption of petroleum in, Galicia in 1896 and 1897.

District.	Metric tons.	Barrels of 42 gallons.
1896.		
Gorlice	29,130	209,459
Jaslo-Krosno	74,870	538,353
Rymanow-Sanok	410	2,948
Ustrzyki-Dolne-Sambor	13,030	93,692
Drohobycz-Schodnica	185,020	1,330,387
Stanislaw-Kolomea	11,060	79,527
Total shipments	313,520	2,254,366
The consumption of crude by—		
Galician refineries	108,250	778,372
Austrian refineries (outside Galicia)	120,050	863,219
Hungarian refineries	84,960	610,905
Exported	260	1,870
Total consumption	313,520	2,254,366
1897.		
Marcinkowice-Gorlice-Zagórzany	29,870	214,780
Skolyszyn-Jaslo-Krosno-Rymanów-Sanok	59,110	425,030
Olszanica-Ustrzyki-Chyrów-Sambor	17,230	123,892
Drohobycz-Boryslaw-Skole-Krechowice	173,570	1,248,055
Stanislawów-Nadwórna-Kolomyja	10,550	75,860
Total shipments	290,330	2,087,617
The consumption of crude by—		
Galician refineries	105,850	761,114
Austrian refineries (outside Galicia)	129,410	930,523
Hungarian refineries	55,070	395,980
Total consumption	290,330	2,087,617

The above figures were given in "Naphtha," an Austrian publication, by Dr. Stanislaus Olszewski, secretary of Galizischen Landes Petroleum Vereines, of Lemberg.

The following table gives the exports of crude petroleum and its products from Austria-Hungary in 1896 and 1897. It will be noticed that there was more benzine exported than there was refined oil, Germany and Switzerland taking nearly the entire product. These countries also absorbed nearly all of the refined petroleum exported. There was a large increase in the amount of benzine exported to Germany in 1897, but a large falling off of refined petroleum.

Exports of crude petroleum and its products from Austria-Hungary in 1896 and 1897.

Quality of oil.	Value.		1896.		1897.	
	In gulden per 100 kilos.	Per quintal.	Metric centners.	Barrels.	Metric centners.	Barrels.
Crude petroleum	2.86	$1.14	18,147	13,049	16,004	11,508
Refined petroleum	4.30	1.72	231,062	183,768	130,824	104,047
Lubricating oil	10.86	4.34	3,131	2,490	13,373	10,636
Benzine	4.13	1.65	182,833	145,410	210,535	167,438
Crude paraffin	27.50	11.00	246	....	37	....
Refined paraffin	33.00	13.20	209	....	235	....
Ozokerite	33.50	13.40	57,215	....	51,525	....
Kerosene	45.00	18.00	23,552	....	13,305	....

Of the total there were exported in 1897, the following:

Quality of oil.	Exported to—	Quantity.
		Metric centners.
Crude petroleum	Italy	6,776
	Germany	6,179
	Trieste	2,939
	Switzerland	2,756
Refined petroleum	Germany	78,937
	Switzerland	45,879
	Trieste	2,939
	Netherlands	1,146
	Belgium	716
	Italy	690
Lubricating oil	Switzerland	5,244
	Germany	4,580
	Italy	1.530
	Servia	1,416
Benzine	Germany	170,066
	Switzerland	16,223
	Bremen	6,161

Exports of crude petroleum and its products from Austria-Hungary in 1896 and 1897—Continued.

Quality of oil.	Exported to—	Quantity.
		Metric centners.
Benzine	Trieste	4,405
	Hamburg	3,650
	England	2,964
	Italy	2,606
	France	2,370
Crude paraffin	Germany	15
	Greece	10
	Roumania	9
Refined paraffin	Italy	55
	Germany	53
	Turkey	46
	Hamburg	23
	Servia	22
Ozokerite	Germany	34,210
	Russia	14,139
	France	1,865
Kerosene	Trieste	4,917
	Italy	1,287
	Hamburg	1,279
	Russia	1,110
	Germany	756
	France	488
	United States	419
	India	426
	Spain	296
	England	273

The following equivalents of value and weight are given:

1 florin or gulden=40 cents.
1 metric ton=2,204.62 pounds.
1 metric ton=7.1905 barrels of crude petroleum of 42 gallons.
1 metric centner } =100 kilos (220.462 pounds).
1 quintal....... }
1 kilo=2.20462 pounds.
1 gallon refined petroleum=6.6 pounds.
1 gallon crude petroleum=7.3 pounds.
1 quintal or 1 metric centner of refined petroleum=0.795317 barrel of 42 gallons.
1 quintal or 1 metric centner of crude petroleum=0.71905 barrel of 42 gallons.

Imports of crude petroleum and its products to Austria-Hungary in 1896 and 1897.

Quality of oil.	Value.		1896.		1897.	
	In gulden per 100 kilos.	Per quintal.	Metric centners.	Barrels.	Metric centners.	Barrels.
Crude petroleum, heavy, sp. gr. more than 0.830	4.30	$1.72	520,526	374,284	480,386	345,422
Crude petroleum *a*	3.20	1.28	157,029	112,912	188,574	135,594
Crude petroleum, light, sp. gr. 0.830 and less	6.50	2.60	12,573	9,041	36,759	26,432
Refined petroleum, heavy, dark, sp. gr. more than 0.880	6.54	2.62	27,881	22,174	52,984	42,139
Refined petroleum, heavy, bright, sp. gr. more than 0.880	7.27	2.91	31,969	25,425	30,744	24,638
Lubricating oils, sp. gr. more than 0.880	7.99	3.20	74,766	59,463	79,990	63,617
Refined petroleum, light, sp. gr. 0.880 and less	6.50	2.60	44,800	35,630	48,852	38,853
Crude paraffin	20.50	8.20	29,424	....	26,710	....
Refined paraffin	25.25	10.10	28,842	....	44,230	....
Benzine	5.00	2.00	18	....	....	....
Ozokerite	30.00	12.00	20	....	24	....
Kerosene	32.00	12.80	72	....	48	....

a Sp. gr. not reported.

Of the total imported in 1897 the following table shows the qualities received and the countries from which imported:

Quality of oil imported into Austria-Hungary in 1897, and countries from which imported.

Quality of oil.	Imported from—	Quantity.
		Metric centners.
Crude petroleum, heavy, sp. gr. more than 0.830.	Russia	478,261
	Roumania	2,080
Crude petroleum *a*	do	188,574
Crude petroleum, light, sp. gr. 0.830 and less.	United States	36,759
Refined petroleum, heavy, dark, sp. gr. more than 0.880.	Russia	47,514
	United States	5,007

a Sp. gr. not reported.

Quality of oil imported into Austria-Hungary in 1897, etc.—Continued.

Quality of oil.	Imported from—	Quantity.
		Metric centners.
Refined petroleum, heavy, bright, sp. gr. more than 0.880.	Russia	29,661
	United States	834
	Germany	111
	England	88
Lubricating oils, sp. gr. more than 0.880.	United States	37,907
	Russia	36,712
	Germany	2,054
	Hamburg	1,441
	Roumania	532
	Turkey	438
	England	323
Refined petroleum, light, sp. gr. 0.880 and less.	United States	43,987
	Germany	1,734
	Italy	1,200
	America	798
Crude paraffin	United States	23,501
	Germany	1,424
	Belgium	780
	England	661
Refined paraffin	United States	26,385
	England	12,749
	Germany	4,277
	Italy	274
Ozokerite	United States	18
	Italy	5
Kerosene	Germany	43

The foregoing table shows a large importation from Russia in 1897 of what is called "crude petroleum, heavy, sp. gr. more than 0.830" (39° B.), the amount being 345,422 barrels. This is a colored distillate which yields a very much larger proportion of illuminating petroleum than does the crude, and is admitted at a reduced rate of duty. Most of it goes to the refineries at Fiume, on the Adriatic Sea. The price of illuminating petroleum was about $12 per barrel at Vienna during 1897. Roumania and the United States both contributed considerable light petroleum to Austria-Hungary, making, with that produced in Galicia, four sources of supply. In 1897 there were 293,630 barrels of petroleum and its products, not including ozokerite, exported from Austria-Hungary, and in the same year there were imported 676,510 barrels, not including paraffin, showing that the imports were greater than the exports by 382,880 barrels, of which about 90,000 barrels came from the United States.

HUNGARY.

For a number of years continued prospecting for petroleum has been going on in Hungary on the flanks of the Carpathian Mountains. The opposite flanks of these mountains, both in Roumania and in Galicia, have furnished a large amount, and the formations are similar. Some petroleum has been found and there are a few barrels produced at points scattered along the flanks of the mountains, but nothing so far has been produced to prove its existence in paying quantities.

ROUMANIA.

The general features of the production of crude petroleum in Roumania were discussed in detail in the report for 1896. All these conditions have remained practically the same in 1897. In the table of production there will be noticed a large increase in the Campina and Busteni fields and a decrease in the Glodeni field. All of the producing localities named are near the foothills of the Carpathian Mountains. The most productive fields are just southeast of the knuckle in this mountain chain, as it sweeps round to the north and northwest. The original method of production was by pits, dug by hand, from 150 to 600 feet deep. The oil was hoisted by buckets, and at this date 75 per cent of all the petroleum produced is secured by this method. The drilled wells range from 900 to 1,300 feet. Very few flow for any length of time. The majority raise the oil by a long cylindrical pump or bailer that works inside of the casing. The loose sand prevents the ordinary pumping appliances. The soft, yielding nature of the material encountered in the drilled wells, together with the workmen's inexperience in this kind of strata, where most of the wells are located, has caused a large number of failures. The inclined strata and, in a number of instances, large bowlders encountered in this soft material divert the bit and cause failure. Nearly all of the principal oil fields are connected by a pipe line with the railroads. At Campina the wells pump, in many instances, direct to the refinery.

Roumania will in the future probably produce much more crude petroleum, as there are many localities that could easily double or triple their present output. The quality of the oil varies considerably; some of it contains a large percentage of paraffin, and others scarcely any. It is easily refined, and produces from 45 to 60 per cent of illuminating oil, 8 to 10 per cent of lubricating oil, 4 to 12 per cent of naphtha, and from 0.5 to 4 per cent of paraffin.

At Campina a refinery has been enlarged to a capacity of 10,000,000 kilograms, or 75,000 barrels, per annum, during 1897, by the "Steaua Romana" company. This company also owns several refineries in Austria-Hungary. There are also large refineries at Bucharest, Mononesti, Tergoviste, and Monteosa. There are about 80 other small refineries scattered over the kingdom, but some of them are so primitive as scarcely to deserve the name.

Of the crude petroleum produced, 70 per cent was refined in the kingdom; the remaining 30 per cent was exported mostly to Austria-Hungary. The price of crude ranged in summer from 2.8 to 4 francs; in winter, from 4 to 5 francs, per 100 kilograms, which is equivalent to 78 cents to $1.12 per barrel in summer and to $1.12 to $1.40 per barrel in winter.

The amount of refined oil produced in Roumania was 230,000 barrels. Of this amount 65 per cent was consumed in the kingdom and 35 per cent exported to Austria, Bulgaria, and the Levant. The price of refined oil was 8 to 10 francs per 100 kilograms in summer, and 14 to 17 francs in winter, which is equivalent to an average of 5½ cents per gallon in summer and 9¼ cents per gallon in winter.

There is an import duty of 20 francs ($4) per 100 kilograms on crude and refined petroleum, less 10 per cent for tare.

The following statement, furnished by the Imperial and Royal Austro-Hungarian consulate in Plojest, gives the production of crude petroleum in Roumania in 1896 and 1897:

Production of crude petroleum in Roumania in 1896 and 1897.

[Tank carloads of 100 metric centners.]

Locality.	Production—	
	1896.	1897.
Baicoi	250	250
Glodeni	1,365	350
Campina	300	1,460
Dolftana and Busteni	2,960	3,830
Ochisori and Matitza	178	150
Sarata (Buzeu) Tega	902	700
Other localities	1,602	1,200
Total	7,557	7,940

One metric centner is equal to 100 kilograms or 220.462 pounds; this multiplied by 100 (as above) gives 22,046.2 pounds; and as a barrel of crude petroleum between 31° and 32° weighs 305 pounds, this amount divided into 22,046.2 gives 72 barrels to each carload of 100 metric centners. The production was 570,886 barrels in 1897 as compared with 543,348 barrels in 1896, a gain of about 5 per cent.

In the following table will be found the production of crude petroleum in the principal districts in Roumania from 1874 to 1897 inclusive.

Production of crude petroleum in Roumania from 1874 to 1897.

Year.	District.				Total.	
	Prahova.	Buzeu.	Bacau.	Dimbovitza.	Tank cars.	Barrels (42 U. S. gallons).
1874	155	780	220	280	1, 435	103, 176. 5
1875	160	820	230	300	1, 510	108, 569
1876	150	760	280	320	1, 510	108, 569
1877	180	760	250	320	1, 510	108, 569
1878	210	750	250	300	1, 510	108, 569
1879	250	700	280	300	1, 530	110, 007
1880	290	710	300	290	1, 590	114, 321
1881	350	740	300	300	1, 690	121, 511
1882	540	700	310	350	1, 900	136, 610
1883	570	700	320	350	1, 940	139, 486
1884	1, 560	700	300	370	2, 930	210, 667
1885	1, 350	700	300	340	2, 690	193, 411
1886	880	750	290	425	2, 345	168, 605. 5
1887	950	800	280	500	2, 530	181, 907
1888	890	840	360	950	3, 040	218, 576
1889	950	1, 010	380	1, 800	4, 140	297, 666
1890	1, 030	1, 100	600	2, 600	5, 330	383, 227
1891	1, 150	1, 050	790	3, 800	6, 790	488, 201
1892	1, 600	1, 100	850	4, 700	8, 250	593, 175
1893	1, 700	950	1, 300	3, 500	7, 450	535, 655
1894	2, 600	925	1, 650	1, 880	7, 055	507, 254. 5
1895	3, 714	904	1, 838	1, 544	8, 000	575, 200
1896	3, 688	902	1, 602	1, 365	7, 557	543, 348
1897	5, 690	700	1, 200	350	7, 940	570, 886

GERMANY.

There are two fields producing crude petroleum in Germany, and the most important is in Alsace. In Prussia, near Hanover, there is another field, of less importance. The former produces 88 per cent of the total. It is located in Lower Alsace, in the valley of the Rhine, some 25 miles north of Strasburg, near the town of Hagenau.

Alsace Lorraine is credited with a production of 147,329 barrels in 1897, an increase of 14 per cent over the production of 1896. The price quoted for 1897 was the equivalent of $2.02 per barrel, as compared with $1.97 in 1896.

The import duty of 6 marks per 100 kilos on illuminating oil, amounting to $1.96 per barrel, and of 10 marks per 100 kilos on lubricating oil.

amounting to $3.25 per barrel, enables both of these fields to be operated at a fair margin of profit.

The oil at Alsace is very dark in color, with a gravity of about 0.876 (28° Baumé), and it contains as it comes from the wells 20 per cent of water, from which it is separated by heating. There is from 25 to 30 per cent of illuminating oil of good quality obtained, together with a large proportion of lubricating oil and paraffin. The largest production as well as the refinery is at Pechelbronn, a few miles out of Hagenau, more fully described in the report of 1896.

The other field in Prussia, many miles to the northeast, near the towns of Wertze and Oelheim, produced 18,493 barrels of crude petroleum in 1897. There are many wells producing a large amount of salt water, which so far it has been impossible to case off, owing to the great number of abandoned wells that have pierced the oil sand. There is also a refinery at Peine that produces a celebrated lubricating oil.

A new oil field is reported to have been found near Voehl, 50 miles north of Strasburg, in the valley of the Rhine, which is supposed to be an extension of the Pechelbronn field.

In 1897 Germany imported 114,583,356 gallons of illuminating oil and 6,877,196 gallons of lubricating oil, making a total of 121,460,552 gallons, equal to 2,892,000 barrels, as compared with 3,500,000 gallons, equal to 83,300 barrels of illuminating and lubricating oils, estimated to have been produced in Germany. The home production is $2\frac{5}{6}$ per cent, or 1 barrel produced to 35 barrels imported from the United States. In 1897 Germany also imported from Russia 7,257,905 gallons of illuminating petroleum, 8,518,810 gallons of lubricating petroleum, and 1,236,865 gallons of crude and distillate, making a total of 405,100 barrels. She also imported from Austria-Hungary 194,820 barrels of illuminating, lubricating, and crude petroleum in 1897.

The production of petroleum in Germany from 1890 to 1897 is shown in the following table:

Production of petroleum in Germany from 1890 to 1897, inclusive.

Year.	Production.	
	Metric tons. (*a*)	Barrels (42 gallons).
1890	15, 226	108, 295
1891	15, 315	108, 927
1892	14, 257	103, 323
1893	13, 974	99, 395
1894	17, 232	122, 563
1895	17, 051	121, 277
1896	20, 395	145, 061
1897	23, 314	165, 822

[a] 1 ton crude -- 7.1126 barrels.

The following table shows the production and value of petroleum in the German Empire from 1894 to 1897, by States:

Production and value of petroleum in the German Empire from 1894 to 1897.

State.	Quantity.		Value.	
	Metric tons.	Barrels.	Marks.	Dollars.
	1894.			
Alsace-Lorraine	15,632	111,183	813,284	195,188
Prussia	1,600	11,380	159,163	38,199
Total	17,232	122,563	972,447	233,387
	1895.			
Alsace-Lorraine	15,439	109,812	776,671	186,401
Prussia	1,612	11,465	185,784	44,588
Total	17,051	121,277	962,455	230,989
	1896.			
Alsace-Lorraine	18,883	134,310	1,001,042	240,250
Prussia	1,512	10,751	187,469	44,993
Total	20,395	145,061	1,188,511	285,243
	1897.			
Alsace-Lorraine	20,714	147,329	1,104,291	264,918
Prussia	2,600	18,493	292,153	70,229
Total	23,314	165,822	1,396,444	335,147

During the year 1896, 396 workmen were engaged in petroleum operations, of which 103 were employed in Prussia, and 293 in other German States.

ITALY.

Little remains to be added to the report of the previous year. The following table shows a decline of 30 per cent in the production in 1896 as compared with that in 1895, notwithstanding the price is quoted at $6.85 per barrel. This high price is due to the import duty on refined, which is 48 lire per 100 kilos, amounting to $11.50 per barrel. There is also an excise tax of 10 lire per 100 kilos on the crude petroleum produced. A number of companies are prospecting, but so far their success has been indifferent, notwithstanding the high price.

In 1896 there were imported from the United States into Italy 22,648,184 gallons of illuminating oil and 1,324,994 gallons of lubricating oil. In 1897 there were imported 24,525,006 gallons of illuminating oil and 1,550,688 gallons of lubricating oil. The production of refined oil in all of the provinces in 1896, as noted in the final table, was only 21,747 barrels, equivalent to 913,374 gallons. During 1897 there were imported from Russia 559,800 gallons of lubricating and 5,862,220 gallons of illuminating petroleum, besides 1,843,840 gallons of crude petroleum.

From the volumes of Rivista del Servizio Minerario the following statements are extracted regarding the production of petroleum in this country:

Production of petroleum in Italy from 1860 to 1896.

Year.	Number of wells in operation.	Quantity.		Production				Number of workmen employed.
		Metric tons.	United States barrels.	Unit value.		Total value.		
				Lire.	Dollars.	Lire.	Dollars.	
1860....	3	5	36	800.00	21.44	4,000	772	5
1861....	5	4	29	800.00	21.31	3,200	618	8
1862....	4	4	29	800.00	21.31	3,200	618	9
1863....	7	8	58	800.00	21.29	6,400	1,235	18
1864....	7	10	72	800.00	21.41	8,000	1,544	32
1865....	10	315	2,265	209.52	5.62	66,000	12,738	70
1866....	12	138	992	269.86	7.21	37,240	7,187	57
1867....	11	110	791	349.10	9.37	38,400	7,411	58
1868....	9	51	367	435.29	11.67	22,200	4,285	52
1869....	8	20	144	800.00	21.65	16,000	3,118	45
1870....	6	12	86	800.00	21.55	9,600	1,853	30
1871....	6	38	273	263.16	7.07	10,000	1,930	40
1872....	6	46	331	208.69	5.60	9,600	1,853	36
1873....	5	65	467	172.31	4.63	11,200	2,162	35
1874....	4	84	604	152.38	4.00	12,800	2,470	37
1875....	3	113	812	138.05	3.70	15,600	3,011	38
1876....	3	402	2,890	123.38	3.31	49,600	9,573	72
1877....	2	408	2,934	132.35	3.55	54,000	10,422	45

Production of petroleum in Italy from 1860 to 1896—Continued.

Year.	Number of wells in operation.	Quantity.		Production.				Number of workmen employed.
				Unit value.		Total value.		
		Metric tons.	United States barrels.	Lire.	Dollars.	Lire.	Dollars.	
1878....	4	602	4,328	102.99	2.76	62,000	11,966	98
1879....	4	402	2,890	124.37	3.34	50,000	9,650	70
1880....	2	283	2,035	313.05	8.40	88,595	17,099	24
1881....	2	172	1,237	445.00	11.94	76,540	14,772	24
1882....	4	183	1,316	474.55	11.97	86,844	15,761	121
1883....	5	225	1,618	259.49	6.96	58,387	11,269	92
1884....	6	397	2,854	341.18	9.16	135,452	26,142	110
1885....	6	270	1,941	407.65	10.92	110,066	21,243	136
1886....	7	219	1,575	416.11	11.16	91,130	17,588	145
1887....	7	208	1,497	364.04	9.76	75,720	14,614	135
1888....	5	174	1,251	319.71	8.58	55,630	10,737	75
1889....	7	177	1,273	288.13	7.73	51,000	9,843	70
1890....	9	417	2,998	289.21	7.77	120,603	23,276	177
1891....	7	1,100	7,909	298.91	8.02	328,800	63,458	230
1893....	8	2,652	19,068	299.80	8.05	795,050	153,445	130
1894....	9	2,854	20,520	296.88	7.97	847,260	163,521	194
1895....	6	3,594	25,841	258.90	6.95	930,496	179,586	134
1896....	7	2,524	18,149	255.34	6.85	644,468	124,383	81

7.1905 barrels in 1 metric ton of crude.
7.955 barrels in 1 metric ton of refined.
1 lira = 19.3 cents.

Production of crude petroleum in Italy in 1895, by districts.

Mining district.	Number of wells.	Production.						Number of laborers.
		Quantity.		Value.				
		Metric tons.	Barrels of 42 gallons.	Per ton.	Per barrel.	Total.	Total.	
				Lire.		*Lire.*		
Emilia......	3	3,532	25,395	260.00	$6.98	918,320	$177,236	114
Roma	3	62	446	196.71	5.27	12,176	2,350	20
Total...	6	3,594	25,841	258.90	6.95	930,496	179,586	134

Production of refined petroleum, benzine, and gasoline in Italy in 1895, by districts.

Mining district.	Province.	Number of works in operation.	Production.						Number of laborers.
			Quantity.		Value.				
			Metric tons.	Barrels of 42 gallons.	Per ton.	Per barrel.	Total.	Total.	
					Lire.		*Lire.*		
Milano.	Parma... Piacenza.	2	4,185	33,291	526.03	$12.76	2,201,464	$424,883	50
Roma..	Chieti...	1	6	48	550.00	13.27	3,300	637	11
Total..	....	3	4,191	33,339	526.07	12.76	2,204,764	425,520	61

Production of refined petroleum in Milano district, Italy, in the year 1895.

Kind of product.	Number of works.	Quantity.			Value.			Number of laborers.
		Metric tons.	Barrels of 42 gallons.	Per ton.	Per barrel.	Total.		
				Lire.		*Lire.*		
Refined petroleum	2	2,902	23,085	559.82	$13.58	1,624,614	$313,551	50
Benzine		638	5,075	499.76	12.12	318,850	61,538	
Gasoline.......		645	5,131	400.00	9.70	258,000	49,794	
Total...	2	4,185	33,291	526.03	12.76	2,201,464	424,883	50

The production of the Chieti district was all reported as illuminating oil.

Production of crude petroleum in Italy in 1896, by districts.

Mining district.	Province.	Number of wells.	Production.						Number of laborers.
			Quantity.		Value.				
			Metric tons.	Barrels of 42 gallons.	Per ton.	Per barrel.	Total.	Total.	
					Lire.		*Lire.*		
Bologna	....	1	1	7	250.00	$7.00	250	$48	23
Milano	Parma........ Piacenza......	5	2,449	17,610	260.34	6.98	637,578	123,053	44
Roma........	Chieti	1	74	532	89.73	2.41	6,640	1,282	14
Total ..	....	7	2,524	18,149	255.34	6.85	644,468	124,383	81

Production of refined petroleum in Italy in 1896, by districts.

Mining district.	Province.	Number of works.	Kind of product.	Production.						Number of laborers.
				Quantity.		Value.				
				Metric tons.	Barrels of 42 gallons.	Per ton.	Per barrel.	Total.	Total.	
						Lire.		*Lire.*		
Milano	Parma....	1	Refined...	1,883.7	14,985	560.09	$13.59	1,055,037	$203,622	30
	Piacenza..	1	Benzine..	828.5	6,591	500.00	12.13	414,250	79,950	
			Heavy oil.	2.5	20	400.00	9.65	1,000	193	
Roma...	Chieti....	1	Refined...	19.0	151	550.00	13.35	10,450	2,017	4
Total.	....	3	....	2,733.7	21,747	541.66	13.14	1,480,737	285,782	34

SUMATRA.

It is probable that nowhere else was there so much capital invested in the development of crude petroleum and refining companies during 1897 as there was in Sumatra. The superior petroleum produced with paraffin base and as light a gravity as 50° Baumé, the large production from comparatively shallow and inexpensive wells, the facilities for refining and exporting the refined products, the distance from any other large producing field, and the many millions of population easily reached in China, Japan, and India, countries that heretofore have furnished only a fraction of their consumption, have given additional interest to the development of Sumatra's resources.

The oldest and by far the most prominent company operating in this country, and the only one manufacturing refined petroleum, was the Koninklyke Petroleum Company, also known as the Royal Dutch Petroleum Company, although there are many companies organized in Holland for the purpose of operating in Sumatra. Several of these are controlled by English capital, although American drilling machinery and American foremen are very extensively employed in the several fields.

Sumatra has two fields developed, about 600 miles apart. The oldest is near Langkat, on the east coast; the other is in Palembang, the most eastern province, and is the more productive. The fields run in a general way parallel to the coast and are from 25 to 75 miles inland. The wells are from 250 to 1,000 feet in depth. The oil comes from loosely cemented irregular deposits of sand alternating with shale. There is usually sufficient gas to make the well flow. A syndicate secured the services of Mr. George Adams, an engineer from London, who visited the subdistricts of upper and lower Lemetang, Kikim, and Pasumah-Lande, district of Palembang, Sumatra, in 1896, and the following is taken from his report:

> At the village of Linggi oil traces are plainly visible on the surface. Water and oil are thrown out continuously at two places. At one of these wells the pressure of gas is very strong. While making a road through the forest a second oil find was

> made at a distance of 6 miles from the former place. Exploration in a third direction led to the discovery of another place where the oil, oozing out of the ground, had been collected and sold by the natives for many years. The difficult nature of the country and the dense vegetation of the virgin forest, as also the shortness of time, made the examination of the oil field at the time rather superficial; yet it was proved beyond a doubt by those three finds that the field extended over an area of 15 square miles, and, judging from numerous spots where the sandstone crops out at the surface, I have arrived at the belief that further investigation will prove the occurrence of oil all over the large area included by the concession. Regarding the transportation of the crude oil little difficulty will be met with. The distance from the field to Palembang, an important seaport on the east coast of Sumatra, is about 100 miles, a Government road following the course of a river for the entire distance. A pipe line could easily be laid along this road, and by cutting off the curves caused by the winding of the river the distance could be shortened by 25 miles. As the oil field is about 400 feet higher than Palembang, the natural fall would make pumping almost unnecessary.

After Mr. Adams's return, Mr. W. C. Knoops was appointed manager and sent to Palembang in December, 1896. Before his arrival there, word was received from Chief Driller Crosbie announcing that at a depth of 215 feet the oil sand had been reached. Mr. Knoops went to the oil field immediately after his arrival in Palembang and telegraphed on January 30 that 1,000 feet south of the first well a second well had been drilled in; 400 feet west of this well a third well was completed on March 15 at a depth of 177 feet. The capacity of the two former wells is estimated at 1,000 barrels a day each, that of the third well where the water had not yet been shut off, at 100 barrels a day. The pressure of gas is enormous. Although the wells were closed after much trouble, the air is impregnated with the escaping gas for a wide distance around the wells. Oil is oozing continuously through the shut-off valves. When opened the oil spurted out 15 feet high. Reporting on the further inspection of the field, Mr. Knoops says that the water of the rivers and creeks is covered everywhere with oil.

After the receipt of these reports the above-named company was organized. The shares were eagerly taken by the public. The company has secured the cooperation of the Messrs. Boverton Redwood and George Adams in the construction of pipe lines, refineries, etc.

By estimating the production for 1896 and 1897 upon the same basis, in the absence of any more precise figures, we make the production of 1896 equal to 696,250 barrels, and that for 1897 1,777,560 barrels, about two and one-half times the production of the year previous, or an increase of 150 per cent. There is no doubt that much more crude could have been obtained if the refiners could have taken care of it.

The Koninklyke Petroleum Company, in 1897, turned out 4,556,245 cases of refined oil, valued at $3,827,246. The amount of crude oil from which this refined was derived is not well known, but could be estimated at about double the quantity in volume, say, 1,777,560 barrels.

The following table gives the production of refined petroleum in Sumatra, in cases, liters, and gallons, from 1893 to 1897, inclusive:

Production of refined petroleum in Sumatra, 1893 to 1897.

Year.	Production.		
	Cases.	Liters.	Gallons.
1893	401,370	14,449,320	3,182,669
1894	1,042,943	37,545,948	8,270,032
1895	1,334,249	48,032,964	10,579,948
1896	1,851,512	66,654,432	14,681,593
1897	4,556,245	164,024,820	36,128,815

A United States gallon = 4.54 liters.
1 case = 36 liters.

In 1896 there was exported to Asia and Oceanica—which includes China, Hongkong, East Indies, Japan, British-Australia—130,454,940 gallons of illuminating petroleum, and 3,000,471 barrels of lubricating petroleum.

BORNEO.

In the Island of Borneo and the island of Labuan, in the northern portion, belonging to England, there are many indications of petroleum and in all probability a production will be obtained there, as the conditions are similar to those of Java and Sumatra.

AUSTRALIA, NEW ZEALAND, AND SOUTH AFRICA.

The following is taken from an article in the Colliery Guardian by Mr. Boverton Redwood, of London:

> But little is known as to the occurrence of petroleum in Australia. Indications are reported to have been met with at York Town, at the extreme end of the York peninsula, between Gulfs Spenser and St. Vincent, and it is said that gas has been found at a depth of about 2,000 feet at Narrabeen, near Sydney. A well was drilled some years ago in the Coprong district, in South Australia, on the site of the deposit of the elastic bituminous substance known as the coorongite, but oil was not found. Extensive deposits of so-called "kerosene shale" occur in New South Wales, and the mineral has been mined and distilled on a large scale for many years by two companies in the same manner as the Scottish shales. The output of shale in New South Wales appears, during recent years, to have been about 40,000 tons per annum. In New Zealand the principal indications of the presence of petroleum occur on the North Island, at New Plymouth and on the Sugar Loaves, and on the opposite side of the island along a belt of country extending from Horoera Point, near the East Cape, where a film of oil is said to be sometimes observed on the sea, to the Okahuatin Block, about 30 miles west of Gisborne (Poverty Bay). At New Plymouth the foreshore is covered with a thick deposit of iron sand, but at low water, wherever the shore is clear of this sand, oil can be seen on lifting the bowlders. Drilling was commenced in this district by two companies in 1865, and oil

was found, but for some reason the work was discontinued. Six years ago a well was drilled by the New Zealand Petroleum and Iron Syndicate close to the beach at New Plymouth. In this well oil was struck at a depth of 915 feet, and the yield was estimated at about four barrels a day. Drilling is being continued by another company, and attention is also being directed to the possibility of finding oil at a spot some distance inland.

In South Africa surface indications of petroleum are reported to have been met with in several places. The Cape Argus last autumn published an account of the oily film which had been observed by the resident magistrate of the district on some of the shallow streams in and around the village of Ceres in Cape Colony, and the confident anticipation was expressed that the entire area of Bokkeveld, including the Ceres and Tulbagh districts, would be found to be oil-bearing. In the English territory of Appolonia, about 40 miles from Axim, on the west coast of Africa, the sandy ground near the sea is in places saturated with petroleum, and a shallow excavation made quickly becomes filled with oil. Several wells drilled in this district have furnished evidence of the existence of a productive deposit of petroleum, but, owing to difficulties met with, the drilling operations have been temporarily suspended.

JAVA.

The first company to operate in the Island of Java was the Dordtsche Petroleum Company of Amsterdam, organized in 1887 with a capital stock of 15,000,000 florins, or $6,000,000, and was reorganized in 1890 as The Dordtsche Petroleum-Industry Maatschappij. Owing to difficulties in disposing of the products on account of the inferior quality of the illuminating oil first manufactured comparatively little oil has been refined for a number of years. This company commenced operations in the districts of Djaba Kota, residency of Soerabaya, and secured leases and concessions of the best oil territories so far developed on the island. Besides extending its operations in the residency of Soerabaya, it opened up the oil field of Rembang in 1893, which proved highly productive. The oil found here is of excellent quality and the output permitted a rapid increase in the production of illuminating oil. The first petroleum was placed upon the market in 1889. The production for the last five years has fluctuated considerably, but the last two years show decided gains. The production of crude petroleum in 1896 was 505,029 barrels; that of 1897 has been placed at 726,373 barrels, a gain of 221,344 barrels, or 44 per cent, over 1896. The indications are that there will be a large increase in the production in 1898.

In Java the only producing company in 1897 was the Dordtsche Petroleum Company before mentioned, which produced 1,452,747 cases of refined petroleum, having a value of $1,133,142. The amount of crude from which this refined was produced is estimated to be twice the quantity in volume, or about 726,373 barrels.

The production of petroleum in Java for five years past is shown in the following table:

Production of crude petroleum in Java from 1893 to 1897.

Year.	Barrels (42 U. S. gallons.
1893	400,000
1894	168,000
1895	293,654
1896	505,029
1897	726,373

Of the 505,029 barrels produced in 1896, 263,564 barrels were produced in Soerabaya and 241,465 in Rembang.

The following statistics, given by the Dordtsche Petroleum-Industry Maatschappij, Java, show their production of crude and refined petroleum during the years 1895, 1896, and 1897 in the districts of Soerabaya and Rembang:

Production of petroleum in Java in 1895, 1896, and 1897, by districts.

	1895.	1896.	1897.
Residency of Soerabaya:			
Crude .... gallons..	8,915,088	11,069,668	11,224,131
Refined .... cases..	525,004	604,418	627,966
Residency of Rembang:			
Crude .... gallons..	3,418,380	10,141,535	7,458,373
Refined .... cases..	222,904	638,916	791,431

At the close of 1897 this company had 34 wells producing in the Soerabaya district and 4 wells producing in the Rembang district.

Production of refined petroleum in Java, 1889 to 1897.

Year.	Production.		
	Cases.	Liters.	Gallons.
1889	8,000	288,000	63,436
1890	27,760	999,360	220,123
1891	79,179	2,850,444	627,851
1892	247,839	8,922,204	1,965,243
1893	276,062	9,938,232	2,189,037
1894	452,728	16,298,208	3,589,914
1895	779,239	28,052,604	6,178,987
1896	1,250,000	45,000,000	9,911,894
1897	1,452,747	52,298,892	11,519,580

The following is taken from a translation by the American Manufacturer from the Chemische und Technische Zeitung:

> The Soerabaya field consists of the Lidah pool with about 25 flowing wells, and the Koetei pool with about 15 partly flowing and partly pumping wells. These two pools produce at present a sufficient quantity of crude to yield 2,000 cases or 20,000 gallons of illuminating oil per day, which production can be increased at any time to 25,000 gallons. Latest reports received from Dutch East India say that two new wells have come in recently in the Lidah pool, producing 80 and 1,400 barrels respectively per day. The Metatoe pool was discovered only a few months ago, and has not yet been connected with the refinery. The material necessary for the pipe line is expected from America shortly. There are now two gushers in this pool, one producing 400 and the other 1,000 barrels per day.
>
> The Rembang field comprises the Panolan pool with 15 flowing wells, which produce sufficient crude for 3,000 cases per day, of which only 1,000 cases can be consumed so far. The latest gusher in this pool came in in January with a daily production of 2,400 barrels. The Tinawoen pool has not been developed to any extent as yet. It belongs to another company, but the production has been secured by the Dordtsche Petroleum-Industry Maatschappij for ten years. The output is estimated at 1,600 cases of illuminating oil daily.
>
> The Dordtsche Petroleum-Industry Maatschappij intends, in the first place, to supply the Java and Madura markets, the consumption of which has increased from about 2,500,000 cases in 1889 to 3,600,000 cases in 1896. Of the latter figure 1,250,000 cases were supplied by this company. This shows that the company can safely treble its production before it needs to look around for outside markets. The transportation facilities are very good. The company controls a fine system for handling its product, consisting of pipe lines, tank cars, reservoirs, and casing houses, which are distributed all over the island.
>
> There are now two refineries in operation, one at Wonokromo for the Soerabaya field, and the other at Ploentoeran for the Rembang field. A third refinery will be built at Samarang in the course of the present year. The new paraffin works at Ploentoeran is now in partial operation. When running full, it will produce 6,000 pounds of paraffin per day. At Wonokromo a factory for lubricating oils is in operation, which now supplies all the sugar factories and railways in Java with this article.
>
> Statistics of the last eight years show that the Javanese production of illuminating oil has increased from 8,000 cases in 1889 to 1,250,000 cases in 1896, and the net earnings of the company from 36,697 florins to 1,923,611 florins. The production for January, 1897, amounted to 108,007 cases, as against 87,577 cases for January, 1896.

JAPAN.

There has been a steady increase in the crude petroleum produced in this country. In 1895 the production was 141,310 barrels, equal to 5,935,031 gallons, as compared with 197,100 barrels, equal to 8,277,450 gallons, in 1896, which is an increase of 40 per cent. The yield per well in Japan has been light. Many of the wells are 1,200 to 1,500 feet deep, though the general range is from 600 to 1,000 feet. The localities where petroleum is produced are usually too crowded with wells, so that their output per well is small and the life of the field shortened. Much of the crude petroleum is of excellent quality, some producing as much as 65 per cent of illuminating oil, while others produce only 25 to 30 per cent. A large proportion of the illuminating oil is mixed with the imported American oil before it is put upon the market.

The importation is about ten times as large as the production. A systematic search is being made for more prolific fields by the geological survey department.

The Province of Echigo, which is about two-thirds of the length of the island from southwest to northeast and on the northern margin, produces over 98 per cent of all the output of the entire kingdom.

Through the courtesy of Mr. K. Nakashima, of the geological survey of Japan, we have received the following interesting statement regarding the production of petroleum in Japan:

"The oil production of 1895, as ascertained by the Mining Bureau, amounted to 149,497 koku (5,935,031 gallons) of crude oil, of which 122,585 koku (4,866,625 gallons), valued at 257,034 yen ($131,344), were sold directly in the crude state to different refining manufactories, and 17,241 koku (684,468 gallons), valued at 94,573 yen ($48,328), were sold in refined state. The production of the most important localities in Japan was as follows:

Production of crude petroleum in the most important districts of Japan in the year 1895.

District.	Production.	
	Koku.	*Gallons.*
Hirei	64,923	2,577,443
Urase	24,353	966,814
Amaze	18,508	734,768
Shiwozawa	17,576	697,767
Total	125,360	4,976,792

"The production of Echigo as a whole is yearly increasing, the yield in 1896 probably amounting to above 208,500 koku, while that of the year 1897 will probably reach, say, 300,000 koku in round numbers. The production in Amaze has declined remarkably, the daily production in 1897 being only 50 koku (from 20 boring wells) in total, while Hirei (Hirei, Urase, and Katsubozawa are all included in one district, being situated, say, 12 kilometers east of Nagaoka town) is now most prosperous, one of the richest wells struck in the latter part of 1897 producing daily above 100 koku (94 barrels) at a depth of 855 feet. The average monthly yield in this section of Nagaoka in 1897 reached 21,000 koku, the richest oil-bearing rock being layers of coarse quartzose sandstone, intercepted by layers of shale, collectively of Tertiary origin, as in other oil fields of Japan."

The production of crude petroleum in Japan from 1875 to 1896, inclusive, is shown in the following table. The production and value of refined petroleum for the same years are given, except for 1896:

Production of petroleum in Japan, 1875 to 1896, inclusive.

Year.	Production.				Value received for crude and refined sold.	
	Crude.		Refined.			
	Koku. (a)	Gallons.	Koku. (a)	Gallons.	Yen. (b)	Dollars.
1875....	4,830	191,751	....	....	....	....
1876....	8,155	323,753	....	....	....	....
1877....	10,114	401,526	....	....	....	....
1878....	18,920	751,124	....	....	....	....
1879....	24,816	985,195	....	....	....	....
1880....	26,974	1,070,868	....	....	....	....
1881....	17,721	703,524	....	....	....	....
1882....	16,450	653,065	....	....	....	....
1883....	21,659	859,862	....	....	....	....
1884....	29,541	1,172,778	6,215	246,735	107,964	55,170
1885....	30,931	1,227,961	7,326	290,842	98,496	50,331
1886....	40,113	1,592,486	13,487	535,434	136,911	69,962
1887....	30,304	1,203,069	8,830	350,551	126,298	64,538
1888....	39,605	1,572,318	4,511	179,087	138,602	70,826
1889....	55,871	2,218,079	7,097	281,751	250,977	128,249
1890....	54,399	2,159,640	11,180	443,846	221,478	113,175
1891....	55,983	2,222,525	13,012	516,576	207,029	105,792
1892....	72,893	2,893,852	13,431	533,211	207,245	105,902
1893....	83,644	3,320,667	10,941	434,358	178,290	91,106
1894....	138,077	5,481,657	13,980	555,006	245,697	125,551
1895....	149,497	5,935,031	17,241	684,468	351,607	179,671
1896....	208,500	8,277,450	(c)	(c)	(c)	(c)
Total.	1,138,997	45,218,181	127,251	5,051,865	2,270,594	1,160,273

[a] 1 koku = 39.7 gallons.

[b] 1 yen = $0.511.

[c] Not ascertained.

The production of crude petroleum in Japan, as ascertained by the Mining Bureau, for the years 1880, 1884, 1885, 1892, 1893, 1894, and 1896, is given, by provinces, in the following table:

Production of crude petroleum in Japan in 1880, 1884, 1885, 1892, 1893, 1894, and 1896, by provinces.

Province.	1880.		1884.		1885.		1892.		1893.		1894.		1896.	
	Koku.	Gallons.	Koku.	Gallons.	Koku.	Gallons.	Koku.	Gallons.	Koku.	Gallons.	Koku.	Gallons.	Koku.	Gallons.
Echigo	22, 607	897, 498	24, 482	971, 935	25, 923	1, 029, 143	69, 042	2, 740, 968	80, 259	3, 186, 282	134, 826	5, 352, 592	205, 348	8, 152, 316
Totoumi	3, 875	153, 838	3, 784	150, 225	3, 630	144, 111	2, 832	112, 430	2, 507	99, 528	2, 548	101, 156	2, 424	96, 233
Ugo	229	9, 091	771	30, 609	805	31, 959	340	13, 498	118	4, 685	345	13, 697	145	5, 756
Shinano	263	10, 441	481	19, 096	425	16, 873	626	24, 852	402	15, 959	248	9, 846	322	12, 783
Ishikari	....	....	23	913	148	5, 875	53	2, 104	78	3, 097	105	4, 168	37	1, 469
Iburi	....	....	....	....	....	....	....	....	280	11, 116	....	....	220	8, 734
Kotsuke	....	....	....	....	....	....	....	....	....	....	5	198	4	159
Total	26, 974	1, 070, 868	29, 541	1, 172, 778	30, 931	1, 227, 961	72, 893	2, 893, 852	83, 644	3, 320, 667	138, 077	5, 481, 657	208, 500	8, 277, 450

Mr. Nakashima says further: "Thus the production in 1896 was some 70,000 koku more than in the preceding year, and this, as usual, is due mostly to the increase in the environs of Nagaoka.

"The most important localities in Echigo, which have yielded above 1,000 koku in 1896, are as follows:

Production of most important localities in Echigo in 1896.

District.	Village.	Production.	
		Koku.	Gallons.
Koshi	Yamamoto and Nigoro	142, 719	5, 665, 953
Naka-Kambara	Tsushima	24, 024	953, 758
Santo	Amaze	17, 795	706, 471
Kariha	Miyagawa	4, 072	161, 645
Nishi-Kubiki	Kami-Nadachi	2, 446	97, 087
Naka-Kubiki	Sugawara	2, 370	94, 073
Total		193, 426	7, 678, 987

"It will be seen from the above table that nearly 69 per cent of the whole production has been supplied by the output of Yamamoto and Nigoro, these two villages including the localities of Hirei, Urase, Katsubozawa, etc., not far from Nagaoka town, situated by the east side of Shinanogawa, one of the largest navigable rivers in Japan, flowing to the Japan Sea by the site of Niygata Harbor.

"Tsushima includes Shiwozawa, Shiwodani, Kanazu, and others, all grouped around the town of Niytsu, northeast about 40 kilometers from the former oil district along the trend of the hills.

"In the town of Amaze borings have been extended a little farther from the seaside to the hill, but as far as I know with no remarkable success, the wells sunk in this direction usually effusing gas and salt water mixed with either little or no oil.

"Miyagawa now forms a somewhat detached locality near the hill facing to the Japan Sea, distant southwest about 10 kilometers from Amaze and west 20 kilometers from Nagaoka. The hill range, after crossing a valley to the east side from it, however, contains here and there oil-yielding localities, collectively known as the oil field of Kariha.

"The oil district of Kami-Nadachi occurs in the western part of Echigo, 15 kilometers west of Takata by direct distance. It has been proved fruitful from working twenty years ago, annually producing from 2,000 to 3,000 koku, all from shafts whose depths vary from 300 to 720 feet. Recently a boring well has been driven and is said to have met a new oil zone in a deeper horizon (1,200 feet) than that which has been previously known.

"Sugawara, known by such localities as Gendoji, Fukazawa, Maya, and Sawada, occurs in the hill not 10 kilometers southwest from the town of Takata, the oil being here produced from shafts, the deepest of which reaches little above 1,000 feet—the deepest shaft ever sunk in whole Echigo.

"Thus, on the whole, our oil production is annually increasing, this increase being due to the development of boring in the localities proved to be comparatively rich. This fact giving impulse to many adventurers, new fields are also sought for boring, though few have succeeded at this date. Probably hopeful localities will appear in the near future. Recently I have heard of a boring well sunk in Totomi which is said to have effused gas and oil from a deeper level than has been attained by shafts up to the present time, but whether it is still yielding or not I have not been informed."

Importation of petroleum into Japan from 1868 to 1894, inclusive.

Year.	Quantity (gallons).	Value.	
		Yen. (a)	Dollars.
1868	31,954	7,236	3,698
1869	5,867	1,662	849
1870	52,711	21,516	10,995
1871	152,296	72,170	36,879
1872	446,804	160,608	82,071
1873	1,000,959	330,599	168,936
1874	1,291,179	306,723	156,735
1875	2,775,354	573,671	293,146
1876	2,888,729	444,134	226,952
1877	2,682,252	605,598	309,461
1878	10,687,753	1,803,076	921,372
1879	16,799,642	2,185,223	1,116,649
1880	14,895,892	1,400,471	715,641
1881	8,007,200	979,112	500,326
1882	20,682,205	2,320,905	1,185,982
1883	23,631,055	2,456,261	1,255,149
1884	17,534,885	1,773,361	906,187
1885	17,636,020	1,667,722	852,206
1886	25,100,220	2,358,498	1,205,192
1887	21,058,865	1,871,428	956,300
1888	28,507,767	3,519,255	1,798,339
1889	36,998,843	4,587,135	2,344,026
1890	42,663,580	4,950,256	2,529,581
1891	40,482,160	4,535,720	2,317,753
1892	32,689,275	3,328,398	1,700,811
1893	49,763,392	4,401,041	2,248,932
1894	55,643,719	5,135,332	2,624,155
Total	474,110,578	51,797,111	26,468,323

a 1 yen = $0.511.

The export of illuminating petroleum in 1894 from the United States to Japan was 37,272,450 gallons.

INDIA.

The production of crude petroleum in India continues to increase, as the tables will show, although the report for 1897 has not been secured.

Most of the production comes from Upper Burma, in the extreme eastern portion of India, on the Irawadi River. Nearly all of it comes from shafts 250 to 325 feet in depth, some of them over a century old. The oil from this section is carted down to the river in earthen vessels, emptied into the holds of the native boats, and floated down the river in bulk. This method has continued for many years. The improved system of drilling is being gradually introduced, and in some of the districts wells 1,000 to 1,200 feet are pumped. Some of these wells when new start off at as high as 50 barrels per day, but gradually decline to nothing.

In Lower Burma petroleum occurs on Arrakan Island. Petroleum occurs in Assam, and is being worked by the Assam Oil Syndicate, as well as by the Assam Railway. The latter company has completed a refinery. In this field is the district of Digboi, where the production is increasing, and 10 wells are now producing. In the district of Makum there are 9 productive wells.

The following, from the pen of Dr. Fritz Noetling, is taken from memoirs of the Geological Survey of India, on the production of petroleum in the district of Burma:

> The present production of Burma is a little over a quarter of a million barrels. So far, therefore, the anticipations as regards the petroleum production of Upper Burma have not been realized. The most important field has been thoroughly tested, and Dr. Noetling doubts whether the future will show any considerable increase. The localities where petroleum is known to occur spread over a considerable area, all the localities being situated on the top of anticlinal arches. The oil occurs in beds of miocene age, and its occurrence seems to be limited to a zone of about 40 miles in breadth, which runs along the eastern side of the Arrakan Yoma. As regards the chemical composition of the oil, much remains to be investigated, because no detailed analysis has yet been made. From a commercial point of view the approximate average composition of Burma petroleum is as follows:

Usual composition of Burma petroleum.

	Per cent.
Illuminating oil	50
Lubricating oil	40
Paraffin wax	10

> The methods of mining employed are exceedingly primitive. There is not the slightest difference in the method of sinking an oil well a hundred years ago and that at present used. A hole 6½ feet square is dug and lined with wooden square set timbering. The tools used for digging consist chiefly of a chisel-shaped iron shoe fixed to a heavy club-shaped wooden handle. The iron shoe is round, slightly tapered, and ends in a double pointed edge. This tool can, of course, be used only in the softest strata. When hard beds are encountered, a lump of iron weighing 150 pounds, pierced at the upper end to allow a rope to pass, is suspended from a

beam laid across the well. The rope is then cut, and the iron falls with sufficient force to produce a considerable hole in the hard rock. As the fall of the iron is so directed that it eventually strikes every point of the bottom, the bed is broken through, but not without great loss of time, for every time the weight has fallen a man is obliged to go down and fasten it to the rope that it may be hauled up again. The appliances used for raising the material are a rude windlass, a leather rope, and an ordinary earthen pot. The miners are lowered by a strong rope which ends in two slings, through which the miner's legs pass. At a given signal the coolies holding the other end of the rope gradually lower the miner into the well. The work of hauling him up again is facilitated by an inclined plane down which the coolies, often eleven in number, run, thus pulling him up more by their weight than by their physical strength. As the time the miner stays below is very limited, on account of the noxious gases, he would not have time, coming from the bright glare of day, to get his eyes accustomed to the darkness. By having his eyes previously tied up, he is enabled to see when down in the well. Before going down he puts on a quaint cap of palm leaves to protect his head from falling stones. The most remarkable feature is the exceedingly small percentage of useful time during which the man is engaged in digging. It varies from 10 to 18 per cent of the total time. This applies, of course, to wells that have reached the oil-bearing strata. In the upper strata a man may stay down for hours without being troubled from the want of air. The cost of a well up to 250 feet may be estimated at 1,200 rupees.

Since 1888 there has been a great increase in the number of productive wells, in their depth and in their output. Although this seems to indicate a prosperous condition of the native oil fields, it is not really so, because the increase has been the result of the sinking of a number of new wells in a district hitherto but little worked. On the other hand, those wells situated in the older parts of the field, which formerly supplied the production, show a distinct decline in yield, notwithstanding their increased depth.

The following table shows the production of petroleum in India from 1889 to 1896.

Production of petroleum in India from 1889 to 1896.

Year.	Production.	
	Gallons.	Barrels (42 U. S. gallons).
1889	3, 298, 737	94, 250
1890	4, 931, 093	140, 888
1891	6, 136, 495	175, 328
1892	8, 725, 331	249, 295
1893	10, 359, 812	295, 994
1894	11, 139, 597	318, 274
1895	13, 013, 990	371, 828
1896	15, 057, 094	430, 203

In the following table is given the production of petroleum in India, by British Provinces and native States, in 1894, 1895, and 1896.

Production of petroleum in India in 1894, 1895, and 1896.[1]

Province or State.	1894.		1895.		1896.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.	*Rupees.*	*Gallons.*	*Rupees.*	*Gallons.*	*Rupees.*
Assam	166,904	33,380	36,435	7,287	238,730	23,873
Burma	10,920,951	1,057,545	12,975,995	1,534,951	14,816,000	1,769,145
Punjab	1,742	409	1,560	353	2,364	337
Native States	50,000	9,375	....	....	....	....
Total	11,139,597	1,100,709	13,013,990	1,542,591	15,057,094	1,793,355

1 rupee = \$0.436.
1 United States gallon = 4.54 liters.

The crude petroleum of Burma furnished 98 per cent of the entire output of India, showing an increase of 14 per cent in 1896 as compared with the previous year.

The Digboi district of the Assam field yielded 235,230 gallons in 1896. There were exported from the United States to India 43,706,780 gallons of illuminating oil in 1896. The total importation of kerosene and mineral oil into India in 1896 was 66,648,001 gallons. The native supply amounted to only about 13 per cent of the total consumption.

GREAT BRITAIN.

The following is an abstract from a paper read before the Imperial Institute on December 20, 1897, by Boverton Redwood:

> The Scottish shale oil industry, which was founded by James Young in 1850, has now grown to very considerable dimensions, the quantity of shale raised in Scotland—chiefly in Midlothian and Linlithgow—during 1896 having amounted to 2,212,382 tons. This yielded, on distillation, 55,309,562 gallons of crude oil. As far back as the beginning of the seventeenth century attention was directed to the escape of inflammable gas from a spring of water near Wigan, and since that time there have been numerous references to the occurrence of petroleum in Lancashire, Shropshire, and elsewhere. The village of Pitchford in Shropshire took its name from a small spring of pitchy petroleum described in Camden's Brittania. Before turning his attention to the distillation of shale, James Young, in 1847, commenced the manufacture of products from a petroleum deposit at the Riddings Colliery at Alfreton, in Derbyshire, to which his attention had been drawn by Lord Playfair. Similar outflows of petroleum had been met with at the Southgate Colliery, Clowne, near Chesterfield, and elsewhere. It is, perhaps not generally known that the annual production of petroleum in this country is sufficiently important to be included in the official returns. The yield increased from 30 tons in 1889 to 260 tons in 1893, but declined to 49 tons in 1894, and to 15 tons in 1895. It may be within the recollection of some that the newspapers, a couple of years ago, reported a find of petroleum near Shepton Mallet, in Somersetshire. The circumstances of the case were peculiar. In an old house, known as Ashwick Court, occupying an isolated position on the north side of the Mendip Hills, on high ground, there was a well which, up to the time referred to, had always furnished the household with good water. Immediately

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[1] Furnished by the Department of Revenue and Agriculture, Calcutta, in "Review of Mineral Production in India for 1894, 1895, and 1896."

after the occurrence of an earthquake shock, this well, for a time, yielded more petroleum than water. It appeared that a servant had filled a saucepan at the pump with water, as she thought, and had put it on the fire, when a strong smell of petroleum was soon observed, and, upon investigation, it was found that the pump furnished a mixture of oil and water. Several barrels were filled with oil from the pump in the course of a few hours. The well, which was 45 feet deep, was sunk in the carboniferous limestone, and, except for a short distance from the surface, was unlined. Exudations of petroleum had been noticed in the same formation at other points along this geological line, notably in the Black Rock quarry near the Avon gorge. Shortly afterwards a similar occurrence of petroleum occurred in a well at a house near Ruabon, but in the latter instance the quantity of oil was smaller.

PRODUCTION AND VALUE.

The mineral statistics of the United Kingdom give the production of petroleum from 1886 to 1896 as follows:

Production of petroleum in Derbyshire, England, from 1886 to 1896.

Year.	Tons (2,240 pounds).	Barrels (42 gallons).
1886	43	314
1887	66	482
1888	35	256
1889	30	219
1890	35	256
1891	100	731
1892	218	1,594
1893	260	1,900
1894	49	358
1895	15	110
1896	12	88

Value of 49 long tons in 1894, £92=$448.
Value of 15 long tons in 1895, £28=$136.
Value of 12 long tons in 1896, £29=$141.

The quantity and value of oil shale produced in Great Britain from 1890 to 1896 are shown in the following table. Most of the oil shale is mined in Scotland.

Production and value of oil shale in Great Britain from 1890 to 1896.

Year.	Production.	Value.
	Tons.	
1890	2,212,250	£608,369
1891	2,361,119	707,177
1892	2,089,937	522,484
1893	1,956,520	489,130
1894	1,986,385	496,596
1895	2,246,865	561,716
1896	2,419,525	604,881

The crude oil varies from about 20 to 30 imperial gallons per ton of 2,240 pounds; the ammonia water, yielding sulphate of ammonia, from 25 to 65 pounds per ton. The products from crude oil vary to a less extent, and from 100 gallons thereof the following may be considered as about an average yield:

Average yield of 100 gallons of crude shale oil.

	Gallons.
Spirits	5
Burning oil	30
Gas oils, 0.840 to 0.865 sp. gr	8
Heavy oils, 0.875 to 0.895 sp. gr	16
Paraffin scale	14
Total	73

There is also a small residue of tar and coke suitable for burning.

The low price of illuminating oil in Great Britain has had a depressing effect upon this industry. The shale-oil manufacturers have had to use the most rigid economy in the separation and marketing of the numerous products derived from the distillation of the shale and the redistillation of the crude shale oil derived from it. The largest part of the supply of this bituminous shale comes from the mines of Midlothian and Linlithgow, in Scotland. There are a number of large manufacturing companies at different localities engaged in refining it and marketing its several derivatives.

IMPORTS INTO THE UNITED KINGDOM.

The following table gives the total importation of petroleum and its products into the United Kingdom for 1896 and 1897 from the United States and Russia·

Total importation of petroleum and its products into the United Kingdom from the United States and Russia for 1896 and 1897.

[Barrels.]

Description.	1896.		1897.	
	From United States.	From Russia.	From United States.	From Russia.
Illuminating petroleum	4,330,600	454,000	4,409,536	559,175
Lubricating petroleum	558,000	55,650	507,174	110,856
Naphtha	172,300		169,670	
Illuminating distillate		230,170		325,395
Crude and residuum		4,010		50,260
Total	5,060,900	743,830	5,086,380	1,045,686

It will be noticed that while imports from the United States remained practically the same for 1896 and 1897, those from Russia increased 40.6 per cent for the same period.

In 1896 the amount imported from Russia was 14.7 per cent of that imported from the United States, as compared with 20.6 per cent of the imports from the United States in 1897.

AFRICA.

The following article is taken from the Oil Paint and Drug Reporter, contributed by Mr. William W. Van-Ness:

Algeria.—Petroleum has been lately found in the province of Oran, Algeria, at a place called Ain-Zeft, by an Englishman, Mr. Armitage. The wells attained a depth of 415 meters, and by means of a pump, between the end of November, 1895, and the beginning of April, 1896, a total of 196 cubic meters of mineral oil was raised. The output, calculated at the commencement at 17 cubic meters a day, fell, at first quickly, then gradually, to 1.35 cubic meters at the end of the experiment. The boring has been deepened for the purpose of penetrating farther into the bed and has now reached a depth of 450 meters. The pump has not, however, since been adjusted; it is therefore unknown if the extra depth will exercise any influence on the output. Another well is being sunk to a depth of 100 meters on the northwest of the first one.

Cape Colony.—Most promising indications, both of gas and oil, are found in the Ceres district of Cape Colony, about 90 miles northeast of Cape Town. The formation here is chiefly Upper Silurian and Devonian, with the strata lying in synclinal and anticlinal beds. It shows no indication of having been either altered or disturbed by the action of the intrusive rocks. The synclinal basins are at some places very wide—in some instances as wide as 12 miles—with well-defined indications of a sump on its vertical axis. Judging from where the strata are exposed in the canyon of the hills above the synclinal valley I should say that the oil occurred in a porous sandstone. The springs of water percolating through this sandstone are, in numerous instances, covered with a film of oil, and in the grass fires burning in the vicinity of this sandstone can be observed little jets of gas which burn occasionally for some days. The formation at one particular point is that of a basin completely surrounded by high hills, the lie of the strata practically conforming to the lie of the basin. The approximate depth of this oil sand would be, I think, between 2,000 and 3,000 feet below the lowest point of this basin. A company, owning several hundred square miles, has been formed to develop this district, but up to the present very little work has been done. I believe, however, they are to start drilling shortly. If oil was struck in this district it could be easily piped by gravity to Cape Town, within a distance of 85 miles, or to the line of the Cape Government Railway, a distance of about 10 miles.

In the Orange Free State, in the vicinity of Heilbrun, indications of oil are found in the Devonian formation at points where intrusive dikes of basalt have cut the formation. The formation here lies practically horizontal, but as most of the country in this vicinity seems to be cobwebbed with intrusive dikes I do not think it likely that the intervening area between these dikes will be of sufficient size to carry a large quantity of oil or give any great pressure.

Indications of oil are also found in the southern portion of Matabeleland, near the junction of the Umzingwani and Limpopo rivers, but no development or systematic prospecting has yet been done at this point.

NATURAL GAS.

By F. H. OLIPHANT.

INTRODUCTION.

The decline in pressure previously noted continued throughout 1897 in nearly all the producing fields. A number of natural-gas companies have extended their lines, and with the help of compressors, have utilized fields that were previously neglected. The life of many wells with declining pressure was longer and furnished more gas than the fall in pressure in the early life of the gas well indicated. Comparatively few new gas wells were drilled during 1897, the main portion of the field work being to keep the older wells free from water and continue their life as long as possible.

Central Ohio and West Virginia furnished some gas wells of large volume and pressure in comparatively new territory.

The increase of $823,910 in the value of production in 1897 over that of 1896 is due to the greater number of companies, principally in Pennsylvania and West Virginia, making returns, and not to increased production. There is difficulty in getting full and complete returns of the numerous small operations scattered throughout the various fields.

The large increase in the number of natural-gas engines throughout nearly all the producing oil fields for pumping oil wells by a system of rods or rope connections has generally proved satisfactory, and the saving in the amount of natural gas formerly consumed in doing the same work is very large. Where deep wells have to be pumped in clusters the condensation in the long steam lines is a serious loss, often amounting to much more than the amount of work accomplished. This can be overcome by the compression of air by natural-gas engines and by slight modifications in the steam cylinders of the engines at the well. They can be arranged to be economical compressed-air engines. The steady increase in the number of incandescent mantles in connection with natural gas is noted, as this combination gives by far the cheapest and best illuminator now offered.

The manner in which the different States are connected by pipe lines carrying gas from one to the other is complicated, and requires considerable careful work to separate the values. New York receives gas from its own territory and also from Pennsylvania and Canada;

Pennsylvania receives some gas from West Virginia; Ohio receives gas from Pennsylvania, Indiana, and West Virginia, besides its own production, and West Virginia receives some gas from Pennsylvania. A part of the gas consumed in Illinois comes from Indiana.

VALUE AND DISTRIBUTION OF NATURAL GAS PRODUCED IN THE UNITED STATES.

The table below shows an increase of $823,910 in the receipts over 1896 for the companies reporting. While this increase is correct for the increased number of companies reporting, it is not a correct comparison, as there were 889 companies reporting in 1897 and only 763 in 1896, a gain of 126. There was a decrease in the receipts of the 763 companies which reported in 1896, although prices were a shade higher in 1897. Much of the amount now sold is by meter, yet there is considerable gas disposed of in small localities near the gas field, the price during the winter and summer months being fixed according to the size of the orifice. Besides these companies making returns there are a number of establishments where gas is largely consumed, such as drilling wells, operating pumping wells and pipe lines, besides that consumed by individuals on whose property there are gas wells and who burn free gas, which will probably amount to an addition to the values reported of from 25 to 30 per cent.

In the following table is given the approximate value of natural gas produced in the United States from 1888 to 1897, by States:

Approximate value of natural gas produced in the United States from 1888 to 1897.

State.	1888.	1889.	1890.	1891.	1892.
Pennsylvania	$19,282,375	$11,593,989	$9,551,025	$7,834,016	$7,376,281
New York	332,500	530,026	552,000	280,000	216,000
Ohio	1,500,000	5,215,669	4,684,300	3,076,325	2,136,000
West Virginia	120,000	12,000	5,400	35,000	500
Indiana	1,320,000	2,075,702	2,302,500	3,942,500	4,716,000
Illinois	....	10,615	6,000	6,000	12,988
Kentucky	....	2,580	30,000	38,993	43,175
Kansas	....	15,873	12,000	5,500	40,795
Missouri	....	35,687	10,500	1,500	3,775
Arkansas	....	375	6,000	250	100
Texas	....	1,728		....	100
Utah	....	150		....	....
South Dakota	....	25		....	....
California	....	12,680	33,000	30,000	55,000
Other States	75,000	1,600,000	1,600,000	250,000	200,000
Total	22,629,875	21,107,099	18,792,725	15,500,084	14,800,714

Approximate value of natural gas produced in the United States, etc.—Continued.

State.	1893.	1894.	1895.	1896.	1897.
Pennsylvania.	$6,488,000	$6,279,000	$5,852,000	[a]$5,528,610	[b]$6,242,543
New York	210,000	249,000	241,530	256,000	200,076
Ohio	1,510,000	1,276,100	1,255,700	1,172,400	1,171,777
West Virginia	123,000	395,000	100,000	[c]640,000	[d]912,528
Indiana	5,718,000	5,437,000	5,203,200	[e]5,043,635	[e]5,009,208
Illinois.......	14,000	15,000	7,500	6,375	5,000
Kentucky	68,500	89,200	98,700	99,000	90,000
Kansas.......	50,000	86,600	112,400	124,750	105,700
Missouri	2,100	4,500	3,500	1,500	500
Arkansas.....	100	100	100	60	40
Texas	50	50	20	....	....
Utah.........	500	500	20,000	20,000	15,050
Colorado	....	12,000	7,000	4,500	4,000
California....	62,000	60,350	55,000	55,682	50,000
Other States..	100,000	50,000	50,000	50,000	20,000
Total...	14,346,250	13,954,400	13,006,650	13,002,512	13,826,422

[a] Includes $912,000 worth of gas produced in Pennsylvania but consumed in New York and Ohio.

[b] Includes $999,882 worth of gas produced in Pennsylvania but consumed in New York, Ohio, and West Virginia.

[c] Includes $126,000 worth of gas produced in West Virginia but consumed in Pennsylvania and Ohio.

[d] Includes $269,336 worth of gas produced in West Virginia but consumed in Pennsylvania and Ohio.

[e] Includes value of some gas produced in Indiana but consumed in Ohio and Illinois.

The following table was compiled from the statements of the same companies and individuals making complete returns in 1897 as in 1896 in Pennsylvania, Indiana, and Ohio. A number of gas companies and individuals do not keep their accounts in such a manner that these tables can be filled out. During 1896 the number of companies that made a sufficiently complete report to fill out the blanks and enable the comparison to be made between 1895 and 1896 were 91 in Pennsylvania, 205 in Indiana, and 59 in Ohio. Sufficiently complete reports for comparison were received in 1896 and 1897 from 115 companies in Pennsylvania, 291 in Indiana, and 87 in Ohio. This shows that the 115 companies in Pennsylvania received more for gas sold in 1897 than in 1896, more gas being sold by meter, while the receipts of 291 companies in Indiana and 87 in Ohio were less.

The number of fires in Pennsylvania and Ohio shows a falling off (more gas being sold by meter), while in Indiana there is an increase. The value of wood or coal displaced is less than the value of the natural gas consumed in Pennsylvania; in Indiana the value of the wood or coal consumed to do the same heating is much more than was paid for the gas; in Ohio the values are nearly the same.

The total number of domestic fires supplied by these companies in the three States named in 1897 was 376,062, as compared with 378,825 in 1896, showing a total decrease of only 2,763 fires.

Natural-gas records in 1896 and 1897.

	Pennsylvania.		Indiana.		Ohio.	
	1896.	1897.	1896.	1897.	1896.	1897.
Amount received for sale of gas or value of gas consumed	$4, 255, 014	$4, 257, 352	$2, 764, 614	$2, 751, 702	$1, 191, 719	$1, 138, 012
Value of coal or wood displaced	$4, 292, 119	$3, 866, 297	$3, 624, 444	$3, 744, 961	$1, 275, 798	$1, 154, 834
Domestic fires supplied	197, 106	187, 644	122, 947	137, 676	58, 772	50, 742
Iron and steel works supplied	38	33	7	10	....	....
Glass works supplied	41	45	36	37	....	1
Other establishments supplied	717	943	865	482	203	170
Total establishments supplied	796	1, 021	908	529	203	171
Total wells producing Jan. 1	1, 655	1, 786	1, 517	1, 748	440	465
Total producing wells drilled	232	222	331	316	119	104
Total wells producing Dec. 31	1, 786	1, 826	1, 748	1, 876	465	447
Total feet of pipe laid	22, 624, 257	23, 932, 250	15, 683, 323	17, 898, 561	7, 395, 172	7, 492, 791
Total establishments reporting	115	115	291	291	87	87

The number of producing wells owned by the companies reporting was 1,786 January 1, 1897, in Pennsylvania; at the close of the year it had increased to 1,826. In Indiana the number of wells producing at the beginning of the year was 1,748; at the close of the year it was 1,876. Ohio showed a reduction in producing wells of from 465 January 1 to 447 December 31.

Each State shows an increase in the number of feet of pipe laid during 1897, Indiana, however, showing the largest increase.

The following table was compiled from the statements of all companies and individuals making returns, and shows the amount received for the sale of the gas in the States where it was consumed in 1897. In several instances not all of it was produced in the State where it was consumed, but was brought into it from the adjoining States. Hence these figures will not check with the table showing the production of gas. There were 889 companies and individuals in the several States named that reported, giving the amount received for gas, together with the value of the coal or wood displaced by it

Value of natural gas consumed in the United States in 1897, by States, and the value of coal or wood displaced by same, as reported by 889 persons, firms, and corporations.

State.	Companies or individuals reporting.	Amount received for sale of gas, or value of gas consumed.	Estimated value of coal or wood displaced by gas.
Pennsylvania	176	a $5, 392, 661	$5, 251, 991
Indiana	452	3, 945, 307	5, 297, 905
Ohio	157	b 1, 506, 454	1, 559, 935
New York	41	c 874, 617	886, 086
West Virginia	12	d 791, 192	881, 259
Kansas	10	98, 517	124, 350
Kentucky	16	89, 312	104, 903
California	8	32, 062	39, 620
Utah and Colorado	3	19, 050	24, 000
Illinois	10	5, 000	5, 000
Missouri	3	158	158
Arkansas	1	40	40
Total	889	12, 754, 370	14, 175, 247

[a] Includes $150,000 worth of gas produced in West Virginia, but consumed in Pennsylvania.

[b] Includes $334,677 worth of gas produced in Pennsylvania, Indiana, and West Virginia, but consumed in Ohio.

[c] Includes $674,541 worth of gas produced in Pennsylvania, but consumed in New York.

[d] Includes $148,000 worth of gas produced in Pennsylvania, but consumed in West Virginia.

USES TO WHICH NATURAL GAS IS APPLIED.

The following table shows the principal uses to which natural gas is applied. The amount consumed as an illuminant increases yearly, but in the table it is not separated from that supplying domestic fires. It will be noticed that 889 companies and individuals reported in 1897, as compared with 763 in 1896, which accounts for the general increase in this table. Much gas is also consumed near the wells in the manufacture of a superior article of lampblack, unreported; and a large amount of natural gas of which we have no record is consumed by individuals and companies inside of the gas belts. A number of iron mills and steel works in and about Pittsburg have their own lines extending to the gas fields.

Uses to which natural gas produced in the United States in 1897 was put, as reported by 889 persons, firms, and corporations.

State.	Companies or individuals reporting.	Domestic fires supplied.	Establishments supplied.				
			Iron mills.	Steel works.	Glass works.	Other establishments.	Total.
Pennsylvania	176	201,059	20	26	57	1,021	1,124
Indiana	452	214,750	11	2	58	864	935
Ohio	157	85,368	1	......	1	181	183
New York	41	55,086	......	......	2	78	80
West Virginia	12	30,015	......	......	5	388	393
Kansas	10	3,956	2	......	......	18	20
Kentucky	16	9,395	......	......	......	1	1
California	8	1,706	......	......	......	2	2
Utah and Colorado	3	640	......	......	......	....	....
Illinois	10	185	......	......	......	1	1
Missouri	3	12	......	......	......	....	....
Arkansas	1	2	......	......	......	....	....
Total	889	602,174	34	28	123	2,554	2,739

RECORD OF WELLS AND PIPE LINES.

In the following table will be found the number of companies and individuals operating, the number of gas wells at the beginning and end of the year, the number of gas wells abandoned during the year, and the nonproducing wells drilled in 1897, together with the total length of pipe (from 2 inches up to 16 inches in diameter) laid up to December 31, 1897, which during the year amounted to a gain of 1,061⅛ miles.

Record of wells and amount of pipe line as reported by 889 persons, firms, and corporations in 1897.

State.	Companies or individuals reporting.	Wells.					Total pipe laid to Dec. 31, 1897.	
		Producing, Dec. 31, 1896.	Producing, drilled in 1897.	Abandoned in 1897.	Producing, Dec. 31, 1897.	Nonproducing holes drilled in 1897.	Feet.	Miles.
Pennsylvania	176	2,124	314	147	2,291	96	28,270,705	5,354+
Indiana	452	2,400	419	230	2,589	66	23,226,981	4,399
Ohio	157	659	88	59	688	51	9,500,472	1,799+
New York	41	286	33	9	310	7	2,186,998	414
West Virginia	12	105	47	2	150	1	4,717,392	893
Kansas	10	61	16	3	74	8	442,570	84
Kentucky	16	69	9	2	76	2	362,580	69
California	8	17	1	......	18	....	54,700	10+
Utah and Colorado	3	18	......	......	18	....	221,200	42
Illinois	10	25	5	......	30	5	47,160	9
Missouri	3	3	......	......	3	....	1,000	½
Arkansas	1	2	......	......	2	....	750	
Total	889	5,769	932	452	6,249	236	69,032,508	13,074½

RECORDS BY STATES.

PENNSYLVANIA.

No new gas territory was opened up during 1897. There were a number of extensions of moderately good territory in some of the fields. All indications point to exhaustion of the several fields more or less rapidly, according to the demand and capacity of the gas pool. As the pressure diminishes it takes more time to obtain an equal quantity of gas. This is at first accomplished by drilling more wells. Then it is found that the gas mains are too small to secure enough gas, and the gas pump is installed. When there is a large demand for gas, suction efficiency is within a few pounds of that of the atmosphere.

Greene County has produced several good gas wells during the year in that deep territory where the Gordon sand is found at from 2,600 to 2,800 feet in depth, and in places another sand, 300 feet below the Gordon, holds gas in fair quantities. What is known as the 30-foot sand, at Nineveh, contains gas and lies above the Gordon sand.

For several years during the introduction of natural gas the great volume was disposed of at prices below its value and consumed in the most uneconomical manner or allowed to escape into the air, when the pressure on the lines ran too high, rather than to shut it in at the wells. The gas companies have been using more care of late years when the end seemed almost in sight, and since the introduction of the meter it has been to the interest of each consumer to use natural gas in the most economical manner. It is probable that to-day 1 cubic foot of gas as now consumed is accomplishing the same results that required 3 or 4 cubic feet for several years after gas was introduced.

The pressure at the wells throughout the State ranges from 1 pound to 700 pounds, and the average is placed at 65 pounds to the square inch. The following table shows a gain in the value of gas produced in 1897, owing to the increased number of natural-gas companies and individuals reporting, 176 in 1897 as compared to 156 in 1896:

Value of natural gas produced in Pennsylvania from 1885 to 1897.

Year.	Value.	Year.	Value.
1885	$4,500,000	1892	$7,376,281
1886	9,000,000	1893	6,488,000
1887	13,749,500	1894	6,279,000
1888	19,282,375	1895	5,852,000
1889	11,593,989	1896	5,528,610
1890	9,551,025	1897	6,242,543
1891	7,834,016		

There were 2,291 wells reported as producing at the close of the year, 314 productive wells drilled, 147 wells abandoned, and 96 dry holes drilled in 1897, by the 176 companies and individuals reporting.

OHIO.

There has been a steady decline throughout almost all of the gas fields in the State except the Lancaster field, which has been extended as far south as Good Hope township in Hocking County. A number of large wells have been found in the vicinity of Sugargrove, in the southeastern corner of Fairfield County. These wells range from 3,000,000 to 6,000,000 cubic feet in twenty-four hours. They are about 2,200 feet in depth, and get the gas in the Clinton horizon. Their rock pressure is about 800 pounds to the square inch. The gas from this district goes to Columbus, Lancaster, Chilicothe, and Athens. This field is by far the most promising in the State, and it is probable that it will be extended still farther south. It has furnished a steady supply to Columbus and Lancaster for a number of years, and the indications are that these cities will continue to enjoy the supply for many years to come.

The falling off in the volume of gas in the Trenton limestone production in northwestern Ohio has been very marked during 1897. The initial pressure in 1888 was 450 pounds to the square inch; that for 1896 was placed at 45 pounds, and that for 1897 at 30 pounds. As the pressure falls many wells are "drowned out" by water, which seals up the flow of gas, and requires more gas to be consumed in the gas compressors to maintain the pressure in the lines, so that the last portions of the gas in the rock will be secured by additional expense, and it is a question whether the limit of its profitable extractions will not be reached in a short time.

The following table shows that the total value of natural gas, as reported in 1897, is only slightly less than that for 1896. There were 27 more companies and individuals reporting in 1897 than in 1896. The decrease in northwestern Ohio is partially compensated by the increase in the Lancaster field.

Value of natural gas produced in Ohio from 1885 to 1897.

Year.	Value.	Year.	Value.
1885	$100,000	1892	$2,136,000
1886	400,000	1893	1,510,000
1887	1,000,000	1894	1,276,100
1888	1,500,000	1895	1,255,700
1889	5,215,669	1896	1,172,400
1890	4,684,300	1897	1,171,777
1891	3,076,325		

The 157 companies and individuals reporting in 1897 show that there were 688 gas wells producing at the close of the year; 88 productive wells were drilled during the year; 59 were abandoned, and 51 were nonproductive.

INDIANA.

The value of the natural gas produced in this State has remained nearly the same for three years past. That of 1897 is slightly less than that of 1896. A large amount of gas goes from this State to Ohio and Illinois. All the gas found in the State comes from the Trenton limestone at an average depth of a little less than 1,000 feet. The original rock pressure in 1886 was 325 pounds to the square inch; in 1896, about 220 pounds; and in 1897 it is placed at 195 pounds. In the Twenty-second Annual Report, Department of Geology, Mr. J. C. Leach, State gas inspector, says: "The average yearly decrease during the past three years has been 20 pounds, the decrease for the past year being about 25 pounds. And in connection with the above it is safe to say that a majority of the wells of the field will cease to be serviceable when the rock pressure reaches 100 pounds." If it were possible to exhaust all of the gas down to 30 pounds there would remain 30 per cent of the original volume at the beginning of the present year, which at the present rate of consumption would last about five years. A considerable portion of the gas area in this State is being invaded by the flow of salt water as the pressure diminishes, and it is a problem to determine how much pressure will be required to restrain the water and keep it from sealing up the flow of gas. Inspector Leach submits the following estimate as to the number of gas wells in the field:

Wells drilled for gas since March 14, 1886	5,400
Wells abandoned since March 14, 1886	2,800
Wells producing gas January 1, 1898	2,600

In the spring of 1897 a considerable amount of oil was found in drilling for gas near Alexander. This was soon followed up by the drilling of about fifty wells in the vicinity, in the heart of the Indiana gas field. Oil was found in about one-half of these wells. Those producing gas alone were plugged, but those producing oil were operated, and a very large waste of gas occurred. The capacity of some of these wells was as great as 6,000,000 to 8,000,000 cubic feet in twenty-four hours, and they were allowed to exhaust for several days. Those producing some oil were operated and a very large amount of gas wasted, which was of more value than the oil obtained. This has been partially corrected by laws enacted by the general assembly in 1893, and further strengthened by a decision of the supreme court, which took the ground that natural gas was confined in a general reservoir, and, being the property of the sovereign, that individuals and companies were restrained from allowing it to go to waste by escaping from wells into the air. The laws regulating the unrestricted flow of natural gas have been the subject of many suits, with varying results, so that their enforcement has been surrounded by legal difficulties.

In the following table will be found a statement of the value of the natural gas produced in Indiana from 1886 to 1897:

Value of natural gas produced in Indiana from 1886 to 1897.

Year.	Value.	Year.	Value.
1886	$300,000	1892	$4,716,000
1887	600,000	1893	5,718,000
1888	1,320,000	1894	5,437,000
1889	2,075,702	1895	5,203,200
1890	2,302,500	1896	5,043,635
1891	3,942,500	1897	5,009,208

The number of wells reported at the close of 1896 was 2,400; 419 were drilled in 1897 and 230 abandoned, so that the number of wells producing December 31, 1897, was 2,589, and the number of dry holes drilled was 66.

KENTUCKY.

Natural gas is produced in Meade, Breckinridge, Hardin, and Jefferson counties in western Kentucky, and in Floyd, Martin, and Lawrence counties in eastern Kentucky.

The wells that supply a part of Louisville and Garnettsville are located in Meade County. These wells are about 480 feet deep and obtain their gas in the Devonian black slate. The pressure has been gradually decreasing, and in cold weather the supply is insufficient.

Some gas is found in Breckinridge County in the neighborhood of Cloverport. The wells are about 950 feet in depth. The gas wells in Hardin and Jefferson counties are small with gradually declining pressure, and the product is consumed by their owners for domestic purposes.

There are many wells having large volumes of gas located at Warfield, Martin County, in eastern Kentucky. They have been shut in for a number of years. Several good gas wells have been developed lately by the New Domain Oil and Gas Company in Floyd County. The gas comes from the top of the "big lime" (Lower Carboniferous) and the Berea sand. None of this gas has been utilized, although there is a company organized expecting to pipe it to the towns on the Ohio River, about 50 miles north.

The following table shows the value of the gas produced in Kentucky in 1897. It shows a slight decline. Nearly all of this amount is produced by the wells in Meade County and sold at Louisville. The length of the pipe line is 35 miles.

Value of natural gas produced in Kentucky from 1889 to 1897.

Year.	Value.	Year.	Value.
1889	$2,580	1894	$89,200
1890	30,000	1895	98,700
1891	38,993	1896	99,000
1892	43,175	1897	90,000
1893	68,500		

The number of wells reported was 69 producing at the close of 1896; 9 were drilled in 1897 and 2 abandoned, leaving 76 wells producing at the close of 1897.

ILLINOIS.

Natural gas is found in Bureau and Randolph counties. In Bureau County the pressure remains steady from 3 to 30 pounds, and the average depth is about 140 to 160 feet. The gas is found in a greensand capped by a hard blue clay. It is used for domestic purposes, and a large number of families have their own gas wells. The supply has been steadily maintained for ten years. In Randolph County there are a number of gas wells (in the town of Sparta) that have furnished a constant supply of gas for eight years, but which at this writing are nearly exhausted. There were 25 producing wells reported at the close of 1896, 5 were drilled that were producers in 1897, making 30 producing at the end of the year.

The production of natural gas in Illinois from 1889 to 1897 was as follows:

Value of natural gas produced in Illinois from 1889 to 1897.

Year.	Value.	Year.	Value.
1889	$10,615	1894	$15,000
1890	6,000	1895	7,500
1891	6,000	1896	6,375
1892	12,988	1897	5,000
1893	14,000		

KANSAS.

The counties in this State in which natural gas is produced are Allen, Wilson, Miami, Montgomery, and Wyandotte.

In Allen County there are a number of good gas wells which have been drawn on for several years, but the decline in pressure is slight. The gas is found at an average depth of 875 feet in a conglomerate of sand and shale after passing through many strata of limestone and shale. The pressure is about 250 pounds to the square inch. Montgomery County has a number of good gas wells of permanent pressure that obtain their gas from the sand rock at an average depth of 675 feet. Others less deep that found gas in shale have ceased production. There are also gas wells in Miami County that are only 300 to 500 feet in depth, but their period of operation is short. Wilson County has a number of moderately good gas wells.

Altogether Kansas has not produced as much gas as was expected from the amount of development during 1896. The production of 1897 shows a considerable falling off. Many gas plants of towns are supplied by the Forest Oil Company, which owns a number of the largest gas wells in the State. The number of producing wells at the close of 1896 was 61, as reported by 10 companies making returns; 16 were drilled in 1897 and 3 were abandoned, leaving 74 producing at the close of 1897. During the year 8 dry holes were drilled.

The production of natural gas in Kansas from 1889 to 1897 has been as follows:

Value of natural gas produced in Kansas from 1889 to 1897.

Year.	Value.	Year.	Value.
1889	$15,873	1894	$86,600
1890	12,000	1895	112,400
1891	5,500	1896	124,750
1892	40,795	1897	105,700
1893	50,000		

MISSOURI.

A small amount of natural gas was produced from shallow wells in Kansas City and was consumed by the owners of the wells for domestic purposes. Bates County has several gas wells showing a pressure of 25 pounds, which also produce a small amount of oil.

CALIFORNIA.

There are many wells producing a small amount of gas scattered in the Sacramento and San Joaquin valleys of California. There are also numerous springs through this region, in which gas is found bubbling up with the water. The range of these springs in some localities is northwesterly to southeasterly, and may mark the line of an old earthquake fracture. The more or less violent folding of the strata in most of this region, together with earthquakes of varying severity, has prevented the accumulation of large reservoirs of high-pressure natural gas throughout these valleys. There may be large reservoirs in the probable anticlinals that are buried under the mass of alluvium that is found.

At Stockton, in the San Joaquin Valley, some 25 wells have been sunk. The wells usually range from 1,000 to 1,400 feet in depth. One of them (an exception to the rule) is 2,500 feet in depth, furnishing gas sufficient to supply a number of families with heat and light. Most of these wells flow gas and water together, and furnish from 20,000 to 50,000 cubic feet per day. The pressure varies from 3.3 inches to 6.8 inches of water.

There are numerous wells which furnish from 1,000 to 20,000 cubic feet, usually associated with flowing water, in Merced, Tulare, and Fresno counties. At Los Angeles there are some wells that flow moderate quantities of gas in the locality of the oil wells, the gas from which is used for generating steam and for domestic purposes.

The production of natural gas in California from 1889 to 1897 has been as follows:

Value of natural gas produced in California from 1889 to 1897.

Year.	Value.	Year.	Value.
1889	$12,680	1894	$60,350
1890	33,000	1895	55,000
1891	30,000	1896	55,682
1892	55,000	1897	50,000
1893	62,000		

NEW YORK.

Natural gas is found in Allegany, Onondaga, Chautauqua, Erie, Oswego, Ontario, Seneca, Livingston, and Cattaraugus counties in a range of strata that begins at the bottom of the Trenton limestone and extends to the Upper Devonian formation.

Most of the gas produced in New York State comes from the vicinity of Wellsville, from wells that are from 900 to 975 feet in depth; the pressure is light but the volume is large, and is found in sand rock of the Upper Devonian formation. There are several gas pools in this county skirting the edge of the oil production, which supply the towns of Andover, Greenwood, Whitesville, Olean in part, Ceres, Nile, Belmont, Friendship, Wellsville, Bolivar, Allentown, and Willing. A considerable amount of gas comes from Ricebrook, in Allegany County. The old original gas well was put down at Fredonia in Chautauqua County, in 1821, and was used for lighting at that date. Most of the wells in this county are small and owned by individual consumers. Baldwinsville, in northwestern Onondaga County, has produced a number of fair wells ranging from 300,000 to 1,500,000 cubic feet per day. These wells vary from 2,000 to 2,850 feet in depth, a number having gone entirely through the Trenton limestone. The rock pressure is reported to be 1,500 pounds to the square inch. The wells in the northern part of Oswego County, which get their gas from the bottom of the Trenton limestone, show large volume at first, but decline at a more rapid rate than many others.[1]

In Erie County the main supply of gas comes from the Medina sandstone. There are a great many shallow wells of slight volume that obtain gas from the Hudson River shale along the south shore of Lake Ontario.

Buffalo and the towns of Getzville, North Tonawanda, Alden, Clarence, and Depew obtain most of their gas from Pennsylvania and Canada. Wells in Livingston County supply the town of Caledonia. The cost of drilling shallow wells is from 90 cents to $1 per foot, and deeper wells cost from $1.25 to $1.50 per foot.

The following table shows apparently a large decrease in the value of natural gas produced in the State during 1897. This is because the previous reports included gas furnished by Pennsylvania and Canada, which was deducted this year.

The value of natural gas produced in New York from 1885 to 1897 is given in the following table:

Value of natural gas produced in New York from 1885 to 1897.

Year.	Value.	Year.	Value.
1885	$196,000	1892	$216,000
1886	210,000	1893	210,000
1887	333,000	1894	249,000
1888	332,500	1895	241,530
1889	530,026	1896	[2] 256,000
1890	552,000	1897	200,076
1891	280,000		

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[1] These wells supply the towns of Pulaski, Lacona, and Sandycreek.

[2] A portion of this amount should be credited to Pennsylvania, but it was impossible to make the separation.

There were 286 producing wells reported at the close of 1896; 33 wells were drilled in 1897 and 9 abandoned, leaving 310 producing wells at the close of 1897; during the year 7 dry holes were drilled.

WEST VIRGINIA.

This State has increased its production over 40 per cent during 1897, reaching a total of $912,528 in value. This amount represents a larger quantity of gas than most of the other values, because only a portion of the towns consuming gas use meters. Of the amount above named, $269,335 was for gas consumed in Pennsylvania and Ohio. Gas is found in Wetzel, Marion, Monongalia, Doddridge, Ritchie, Tyler, Harrison, Pleasants, Wood, Marshall, Kanawha, and Logan counties. The sands supplied in gas are the Cow Run Salt Sand, Big Injun, Gantz, Fifty-foot, Gordon, Fourth, Fifth, and Elizabeth sands. The depth of gas wells ranges from 1,200 to 2,800 feet, and the rock pressure varies from 100 to 1,100 pounds to the square inch. In the Mannington district the largest part of the gas comes from Fourth sand wells, and there has been a considerable decline in pressure. In Wetzel County the Big Injun and Gordon sands furnish a large portion of the gas. In the latter part of 1897 a well was drilled in, southwest of Pinegrove, in Wetzel County, on the Cunningham farm. It could not be controlled for several weeks, and was said to have been equal to the "Big Moses" well some 10 miles farther south when it was first opened up. There were several other large gas wells developed in this section. The price for drilling ranges from $1 to $1.50 per foot. There is a large falling off in the pressure of several of the fields. There are three lines leading out of West Virginia, namely, the Philadelphia Gas Company, from Tyler County to Pittsburg; The Wheeling Natural Gas Company, from Cameron to Wheeling and to Bridgeport, Ohio; and The Mountain State Gas Company, from Pleasants County to Marietta, Ohio. The following cities and towns are also supplied: Wheeling, Parkersburg, Sistersville, New Martinsville, St. Marys, Morgantown, Mannington, Fairmont, Clarksburg, Weston, Moundsville, Cameron, and Cairo, besides many smaller places. There were 105 producing wells reported at the close of 1896; 47 wells were drilled in 1897, and 2 abandoned, leaving 150 wells producing at the close of 1897; 1 well was dry.

COLORADO.

The value of the natural gas produced in Colorado has been placed at $4,000 in 1897, as compared with $4,500 in 1896. A considerable portion is used for drilling wells, the value of which was not fully determined.

No attempt has been made to drill for gas alone. Its occurrence is incidental to the production of petroleum in the Florence field. Several abandoned oil wells produce enough gas to supply part of Florence for domestic purposes. Gas has a maximum pressure at the well of about 10 ounces, and is pumped from the wells into the mains and delivered under service pressure of 8 to 16 ounces. More or less is used in drilling and pumping, of which no estimate is made.

UTAH.

During the year 1897 the Salt Lake and Ogden Gas and Electric Company was absorbed by the Union Light and Power Company of Salt Lake City, Utah. It is reported that 43,000,000 cubic feet of natural gas was produced and consumed in 1897. The wells are from 400 to 600 feet in depth and originally had a pressure of 140 to 240 pounds to the square inch, according to their depth.

Constant trouble has been experienced in keeping the wells open, owing to the silting of the slate and sand, which settles to the bottom and chokes up the flow. Several new wells were added to the plant. These wells are located 12 miles north of Salt Lake City, on the shore of Salt Lake. The analysis of this gas in the report for 1896, from an analysis made for the Salt Lake and Ogden Gas and Electric Company, gave 16.6 per cent of free hydrogen. Dr. F. C. Phillips, of the University of Western Pennsylvania, made an analysis of this gas for free hydrogen and failed to find a trace with the most delicate test by the use of pure dry palladium chloride. The following is taken from a paper read before the chemical section of the Society of Western Pennsylvania November 18, 1897: "It seems safe therefore to assert that free hydrogen does not occur in natural gas from the Great Salt Lake, and that the gas of recent origin from that region does not differ from that produced from the Devonian rocks of Pennsylvania, as regards the presence of free hydrogen."

Value of natural gas produced in Utah from 1893 to 1897.

Year.	Value.
1893	$500
1894	500
1895	20,000
1896	20,000
1897	15,050

CANADA.

Very little remains to be added to the report for 1896. The two fields that furnish nearly all the natural gas are the Essex and Welland fields—the former near the western extremity and the latter near the eastern extremity of Lake Erie. There are about 34 wells producing in the Essex field and 106 in the Welland field.

More gas was furnished in 1897 than in 1896 and was valued at the wells at $308,448. The largest markets for the natural gas are Detroit, Michigan, and Buffalo, New York, in the United States. There is some production in the neighborhood of Petrolia and Oil Springs, Lamberton and Kent counties, that supplies domestic requirements of quite a number of families.

The following table shows the number of producing wells, miles of pipe, workmen employed, value of the gas product at the point of production, and the wages for labor:

Statistics of natural gas in Canada.

Year.	Producing wells.	Miles of gas pipe.	Workmen employed.	Value of gas product.	Wages of labor.
1893	107	117	59	$238,200	$24,592
1894	110	183½	99	204,179	53,130
1895	123	248	92	282,986	73,328
1896	141	287¼	87	276,710	47,527
1897	140	297	84	308,448	42,338

The following table shows the value of natural gas produced in Canada, including that delivered in the United States at the cities of Buffalo and Detroit by pipe lines, from 1892 to 1897:

Value of natural gas produced in Canada from 1892 to 1897.

Year.	Value.
1892	$150,000
1893	366,233
1894	313,754
1895	423,032
1896	276,301
1897	325,873

IMPORTS.

The foreign value of the natural gas exported from Canada into the United States and delivered at Detroit, Michigan, and Buffalo, New York, as nearly as could be ascertained from partial reports and estimates, is placed at $250,000.

HYDROGEN SULPHIDE IN THE NATURAL GAS OF POINT ABINO, CANADA.

In the Journal of the American Chemical Society, for September, 1898, Prof. Francis C. Phillips, Allegheny University, discusses the occurrence of this impurity in the Abino natural gas. Point Abino is a promontory extending into Lake Erie from the northern shore, and is about 10 miles west of Buffalo. It is the southern extremity of the important gas field from which Buffalo obtains a large part of its natural gas.

The Provincial Natural Gas Company drilled a 600-foot well near the end of the point in 1892 and gas was found at a depth of 350 feet, and again at 400 feet, or at the base of the Niagara limestone. The Abino gas differs a good deal from the gas found in the Devonian rocks of western Pennsylvania in that it contains hydrogen sulphide (sulphureted hydrogen) and yields sulphur dioxide on combustion.

Natural gas from the Niagara limestone is apt to contain hydrogen sulphide, and although some pockets of this impurity are encountered which soon become exhausted, yet it not infrequently happens that over long periods it continues to be an objectionable ingredient of commercial natural gas.

Under the city of Niagara Falls, at a depth of 50 to 60 feet, hydrogen sulphide caused serious annoyance to the workmen engaged in excavating a sewage tunnel, and it was met with at about the same depth by the Cataract Construction Company in working on the wheel pit and tunnel shaft. It accompanies the gas found near Fort Erie, at more than one place between Buffalo and Point Abino, and at Port Colborne, 20 miles west of Buffalo, as also at Chippewa, south of Niagara Falls, and at Alden, 18 miles east of Buffalo. Professor Phillips says: "The sulphur gas is found in wells distributed over a territory extending irregularly for about 40 miles east and west and about 20 miles north and south" (of Buffalo).

In this region there are three other horizons which yield gas, all of them below the Niagara limestone, the Clinton, the Medina sandstone, and the Trenton limestone—the latter rock occurring at a depth of 2,940 feet 6 miles north of Point Abino. But hydrogen sulphide seems to be an invariable accompaniment only of the gas from the Niagara limestone.

In testing the Abino gas for organic sulphides, such as methyl and ethyl sulphide, negative results were obtained, as also for ethylene. The composition of the gas was as follows: Hydrogen sulphide, 0.74; nitrogen, 2.69; carbon dioxide, trace; hydrocarbons of the paraffin series, 96.57.

The composition of the paraffins, by weight, was: hydrogen, 24.10; carbon, 75.90.

This analysis was made in September, 1896. Other samples of the Abino gas were taken in September, 1897, and the amount of hydrogen sulphide found was 0.82 per cent. Taking the production of the Point Abino well at 1,000,000 cubic feet per day, according to the statement of Mr. E. Coste, engineer for the company, Professor Phillips calculates that the amount of hydrogen sulphide burned to sulphur dioxide is equivalent to 600 pounds of sulphur per day, or 115 tons in one year. While the full capacity of the well is not used, yet there are other wells yielding sulphur gas, so that the amount of sulphur dioxide in the atmosphere around Buffalo must be very large.

As to the origin of the hydrogen sulphide in the natural gas from the Niagara limestone nothing very definite is known. It may be connected with the occurrence of gypsum in the region. Under this head Professor Phillips remarks as follows:

> If a genetic relationship exist, as is suggested by their association, it is difficult to determine whether the hydrogen sulphide, by oxidation in presence of limestone, has produced gypsum or whether the gypsum has, by decomposition, yielded hydrogen sulphide. If hydrogen sulphide has undergone oxidation there seems to be reason to suppose that the process must have occasionally remained incomplete when occurring at great depths, and have resulted in the setting free of sulphur. Sulphur does not appear to occur native in the region. If the hydrogen sulphide has penetrated from greater depths to undergo oxidation in the higher strata, it should be found more abundantly in the lower gas-bearing rocks, instead of being confined to the uppermost of these, viz, the Niagara limestone.
>
> On the other hand, the production of hydrogen sulphide from gypsum would seem to require an exposure to high temperature in presence of hydrocarbons—conditions which can not have occurred. No one of the constituents of natural gas could, at temperatures existing in the stratified rocks of the region, have produced hydrogen sulphide by its action upon gypsum.

In the same article Professor Phillips describes a new method for the determination of sulphur in gas mixtures, by which a measured volume of gas is burned in an oxygen atmosphere, the sulphuric acid absorbed in sodium hypo-bromite solution and precipitated as barium sulphate. While the principle is not new, yet some excellent improvements have been made in the apparatus, etc., e. g., the use of pure carbon monoxide to mix with the natural gas before oxygen is admitted, the concentric arrangement of the burner tubes so that the issuing oxygen shall encircle the flame of gas burning from a platinum tip, etc.

ASPHALTUM.

By EDWARD W. PARKER.

PRODUCTION.

Under the general head of asphaltum in these reports are included all of many varieties of bitumens which are produced on a commercial scale. The different varieties embrace the nearly liquid form characterized specifically as maltha or brea; the sandstones and limestones impregnated with bitumen and termed "bituminous rock," and the numerous forms of hard asphaltum to which, from peculiar characteristics or in honor of the discoverer, special names have been given, such as albertite, elaterite, gilsonite, wurtzelite, lithocarbon, etc.

The following table shows the annual production of asphaltum and bituminous rock in the United States since 1882:

Production of asphaltum and bituminous rock from 1882 to 1897.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1882........	3,000	$10,500	1890........	40,841	$190,416
1883........	3,000	10,500	1891........	45,054	242,264
1884........	3,000	10,500	1892........	87,680	445,375
1885........	3,000	10,500	1893........	47,779	372,232
1886........	3,500	14,000	1894........	60,570	353,400
1887........	4,000	16,000	1895........	68,163	348,281
1888........	50,450	187,500	1896........	80,503	577,563
1889........	51,735	171,537	1897........	75,945	664,632

As will be seen from the foregoing table, the aggregate production of asphaltum, bituminous rock, etc., in 1897 amounted to 75,945 short tons, valued at $664,632, against 80,503 short tons in 1896, worth $577,563. It will be seen by this that while the output in 1897 decreased 4,558 short tons, the value not only showed a marked increase ($87,069), but reached the highest figure ever recorded. This increase in value was not due to any advance in values, but rather to an increase in the production of hard, gum, or refined bitumen, and an increase also in the output of maltha or brea, which sells for a higher price than the ordinary crude asphaltum and bituminous rock, all varieties of which showed a decreased production. Crude asphaltum, for instance, showed a decrease in production from 6,500 tons in 1896 to 5,971 tons in 1897, while the average price per ton was practically the same, there being only a difference of 4 cents in the two years. The production of bituminous sandstone decreased from 56,971 short tons in 1896 to 48,801 tons in 1897. The average price per ton of this product increased from $3 to $3.25. In the production of bituminous limestone there was a decrease of over 50 per cent, from 4,300 tons in 1896 to 2,100 tons in 1897, with a difference of only half a cent in the average price per ton. The increases were in the production of mastic, liquid asphaltum, and in that of hard and refined "gum" asphaltum. In the latter are included "gilsonite" from Colorado and Utah, hard "Ventura" asphaltum from Ventura County, California, and all gum or solid bitumen refined before being sold. The production of liquid asphaltum increased a little over 50 per cent, from 9,510 tons in 1896 to 14,650 tons in 1897. The average price fell from $22.50 per ton to $21.25. The production of hard and refined asphaltum increased from 3,122 short tons in 1896 to 3,940 tons in 1897. The increase in value was from $92,240 to $102,000, indicating a decrease in the average price per ton. This decline was from $29.58 in 1896 to $26 in 1897. The amount of asphaltum sold in the form of "mastic" (that is, ground or masticated, heated, and pressed into blocks for convenient shipment) increased from 100 tons in 1896 to 483 tons in 1897. The average price per ton was $9 in 1896, and a little over $20 in 1897, the increase in price being due to a product of this material reported from California in 1897 on which a higher value was placed. No mastic was reported from this State in 1896.

It will be seen, then, that the comparative increase in value was in spite of lower prices, instead of because of higher values. The increase of 25 cents per ton in the price of bituminous sandstone meant an increase of $12,200 over the value of the same amount of product at the price obtained in 1896. But if the prices for the maltha and hard asphaltum had been the same in 1897 as in 1896, the value would have increased about $32,400, so that comparatively there was a decrease in value of about $20,000. The higher value of mastic in 1897 partly offset this decrease, but, taken at the same prices for all kinds as obtained in 1896, the value in 1897 would have been nearly $675,000 instead of $664,632.

The following table exhibits the production and value of the several kinds of asphaltum and asphaltum products in 1896 and 1897. Both the amounts and value are for the product in the condition in which it was first sold.

Varieties of asphaltum, etc., produced in 1896 and 1897.

Variety.	1896.		1897.	
	Short tons.	Value.	Short tons.	Value.
Crude asphaltum	6, 500	$78, 000	5, 971	$71, 404
Bituminous sandstone	56, 971	170, 913	48, 801	158, 914
Bituminous limestone (*a*)	4, 300	21, 500	2, 100	10, 600
Mastic	100	900	483	9, 864
Hard, refined, or gum	3, 122	92, 240	3, 940	102, 500
Liquid or maltha	9, 510	214, 010	14, 650	311, 350
Total	80, 503	577, 563	75, 945	664, 632

[a] Not including mastic or refined asphaltum made from bituminous limestone.

PRODUCTION BY STATES.

Considering the production by States, it is to be noted that there were seven States and Territories that contributed to the product in 1897 against four in 1896. The four States from which the product was obtained in 1896 were California, Colorado, Texas. and Utah. Kentucky, which reported an output of 5,383 short tons in 1894 and 2,359 tons in 1895, had no product in 1896, but resumed production again in 1897, with an output of 3,250 tons, while new mines opened in the Indian Territory and Oklahoma added those Territories to the list of producers, with a combined product of 280 short tons. All of the small product from Texas in 1897 (65 tons) was from Montague County, the litho-carbon property in Uvalde County being in the hands of a receiver and nonproductive. The production in California, the most important producing State, decreased from 74,471 short tons in 1896 to 68,650 tons in 1897, while the value of the product increased over 20 per cent, from $492,663 to $598,502. This increase in value in the face of a decreased output was due to a falling off of over 12,000 tons in the production of crude asphaltum and bituminous rock and an increase of 700 tons in the production of hard Ventura asphaltum and of 5,150 tons in the production of liquid asphaltum or maltha, while an addition of 403 tons of mastic augmented the value by $9,000. The combined product of Colorado and Utah increased from 3,170 short tons in 1896 to 3,700 tons in 1897, with a decrease in value from $49.680 to $47,500, a condition exactly the reverse of that which obtained in California. The production of Colorado and Utah is combined, and further discussion of the industry in these States is omitted in order to maintain the confidential nature of individual statements which are furnished this office.

In the following table will be found the amount and value of the asphaltum production during the past four years, by States:

Production of asphaltum since 1894, by States.

State.	1894.		1895.		1896.		1897.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
California	51,187	$251,991	64,046	$284,086	74,471	$492,663	68,650	$598,502
Kentucky	5,383	21,409	2,359	11,795	....	....	3,250	15,150
Indian Territory, Oklahoma, and Texas	[a] 3,000	45,000	[a] 1,058	29,900	[b] 2,862	35,220	345	3,480
Colorado and Utah	1,000	35,000	700	22,500	3,170	49,680	3,700	47,500
Total	60,570	353,400	68,163	348,281	80,503	577,563	75,945	664,632

[a] Texas only.

[b] Indian Territory and Texas.

CALIFORNIA.

California stands in the same relation to the other asphaltum-producing States as Pennsylvania does to the coal producers; that is, so far ahead in both the amount and the value of the product as to preclude all chance of being supplanted for many decades to come. California's contribution to the asphaltum production in 1897 was a little over 90 per cent of the total. In value the asphaltum from California represented a fraction less than 90 per cent. During the last four years the average proportion of California's product to the total has been the same as in 1897—90 per cent. The lowest proportion was in 1894, when California produced 84.5 per cent; the highest, in 1895, with 95.4 per cent. In value California has produced an average of 84 per cent during the last four years.

There are six counties in the State in which asphaltum is mined—Kern, Monterey, San Luis Obispo, Santa Barbara, Santa Cruz, and Ventura. They are all in the southern half of the State, and all except Kern County border on the ocean, and in some cases the asphaltum deposits are close to the shore, so that the product can be loaded into vessels directly from the mine. Hard asphaltum is produced in Santa Barbara and Ventura counties. Liquid asphaltum, or maltha, is produced in Santa Barbara and Kern counties; and the product from the other three counties is bituminous rock. The liquid asphaltum is used as a flux in reducing the harder varieties to the proper consistency for cementing purposes. For this purpose it is claimed to be very superior to coal tar and petroleum residuum.

In previous volumes of Mineral Resources, analyses of different California asphaltums have been published. The following is an analysis, made by Dr. Frederick Salathe, of material from the Waldorf mine of the Consolidated Asphalt Company, Santa Barbara County:

Analysis of asphaltum from Waldorf mine, Santa Barbara County, California.

	Per cent.
Total bitumen, soluble in chloroform	76.20
Moisture	1.80
Mineral residue (infusorial earth)	22.00
Organic matter, insoluble	Traces.
Total	100.00

The relation of retinoid (petrolene) to retene (asphaltene) in the pure bitumen extracted from the same material is as follows:

	Per cent.
Retinoid (petrolene)	64.15
Retene (asphaltene)	35.85
Free sulphur	None.
Combined sulphur	.60

Dr. Salathe recommends this asphaltum for paving purposes upon the following grounds: (1) The complete uniform mixture, penetration, and cementation which exist between the bitumen and mineral matter; (2) the small percentage of moisture, which facilitates fluxing; (3) the physical properties of the pure bitumen, such as toughness, elasticity, and cohesion; (4) the retinoid or petrolene and retene or asphaltene, which constitute the bitumen, are in such proportions that the asphaltene is held in complete solution by the petrolene and will not precipitate in powdered form, one of the main causes of disintegration in some asphalts.

Following is a published analysis of hard asphaltum from the Ventura County mines of the California Asphaltum Company:

Analysis of Ventura County, California, asphaltum.

	Per cent.
Bitumen, soluble in 95 per cent alcohol	5
Bitumen, soluble in ether	54
Petrolene	70.30
Asphaltene	29.47
Foreign matter	.23
Total bitumen	99.77
Moisture	.03
Fixed carbon	.12
Mineral matter (ash)	.08
Total	100.00

The production of asphaltum in California on a commercial scale began in 1888. The product in that year consisted entirely of bituminous sandstone, which was used for street paving. In the following year considerable attention was paid to the refining of some of the natural product for the manufacture of varnishes, insulators, and protective covering for wharf piling and timbers, wood conduits, etc. During these first two years of the asphaltum industry in California the business was somewhat overdone and a reaction set in. The conditions were not ripe for a revolution in the system of street paving, and it is for this purpose that the bituminous sandstones of California are especially adapted. Moreover, those who had engaged in the enterprise had done so without sufficient knowledge. It is now well known that asphalt pavements are serviceable and enduring only when proper attention has been given to preparation of the foundation, laying of the base, and technical treatment and laying of the asphalt itself. More than this, owing to the great differences in the qualities of various asphaltums and bituminous rocks, each must be studied for itself in order to obtain the best results. Because one asphaltum, treated by the same process to which another has been subjected, does not give as satisfactory results, it is not necessarily a reflection on the quality of the former. It may be really better than the other. The trouble has been with the preparation. To the lack of technical knowledge in regard to the California asphaltums may be attributed the unsatisfactory result from their earlier applications and the collapse of several companies which engaged in the business. More intelligent application has corrected this error, and the superior qualities claimed for the California asphaltums have not only been demonstrated at home, but have secured for them recognition and markets abroad. The increased production in the last five years is ample evidence of this fact.

The production of bituminous rock in California during 1897 was 20 per cent, or 11,545 tons less than in 1896, which was partly made up by a small increase in the production of crude hard asphaltum and refined gum and an increase of over 5,000 tons, a little more than 50 per cent of maltha or liquid asphaltum. The increase in these and the addition of 403 tons of mastic had the effect of increasing the total value more than $100,000 in spite of the decrease in the output of bituminous rock. This is readily understood when it is stated that the average price for bituminous rock in 1897 was $3.15 per ton, whereas hard asphaltum brought from $12 to $20 per ton and the average price for liquid asphaltum was a little over $21 per ton. The total value of the asphaltum produced in California in 1897 was the largest ever obtained.

The following table gives the annual production of asphaltum and bituminous rock in California since 1888:

Annual production of asphaltum, etc., in California since 1888.

Year.	Bituminous rock.	Hard asphaltum.	Maltha.	Total.	Total value.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	
1888	49,300	....	....	49,300	$152,500
1889	47,968	....	....	47,968	126,885
1890	....	....	....	(*a*)	(*a*)
1891	39,962	....	....	39,962	154,164
1892	24,000	6,250	1,300	31,550	188,350
1893	33,000	*b* 9,650	....	42,650	275,662
1894	45,397	*b* 5,790	....	51,187	251,991
1895	38,921	21,375	3,750	64,046	284,086
1896	56,971	*c* 8,000	9,500	74,471	492,663
1897	45,426	*d* 8,574	14,650	68,650	598,502

a Not reported by States.
b Includes maltha or liquid asphaltum.
c Includes hard crude asphaltum and refined gum.
d Includes hard asphaltum, mastic, and gum.

KENTUCKY.

Two counties in Kentucky are credited with asphaltum production in 1897—Breckinridge and Logan. Grayson County has produced some in former years, but the deposits were not worked either in 1896 or in 1897. The entire product of Kentucky is in the form of bituminous sandstone. The output from Logan County is from a recently opened deposit near Russellville. The asphaltum or bituminous sandstone deposit is at the top of a hill, and covers about 550 acres, practically level. The stratum of bituminous sandstone is from 6 to 20 feet thick, with an overburden of earth from 2 to 10 feet thick. The overburden is stripped off and the bituminous rock quarried out. At present only hand labor is employed in drilling and handling the material. Dynamite is used to blast it. The company operating this deposit has acquired other properties of a similar character in Warren and Butler counties which it expects to have in operation during 1898.

No production was reported from any of the Kentucky deposits in 1896. The first product from the State was obtained in 1891, since which time the output has been as follows:

Annual production of bituminous sandstone in Kentucky from 1891 to 1897.

Year.	Short tons.	Value.
1891	3,000	$6,000
1892	2,680	10,525
1893	1,929	6,570
1894	5,383	21,409
1895	2,359	11,795
1896	None.	None.
1897	3,250	15,150

OKLAHOMA TERRITORY.

The asphaltum deposits near Oklahoma City, of which mention was made in the report for 1896, were opened up in 1897, and yielded an output of 60 short tons. Mr. George F. Devereux, M. E., states that the company operating the deposit has placed a large amount of machinery on the ground and will be able to produce 100 tons of asphaltum per day. Additional railway facilities for the transportation of the material have also been obtained, and an increase of business for 1898 is confidently anticipated.

INDIAN TERRITORY.

About 100 miles a little east of south from the Oklahoma deposits, in the Chickasaw Nation of the Indian Territory, are deposits of bituminous limestone and bituminous sandstone. The first production from this locality was reported in 1897, consisting of 200 tons of the former and 340 tons of the latter. Some of this was sold crude (100 tons); 80 tons was sold as mastic, 2,300 pounds of crude being used to make 1 ton of mastic, while refined gum asphaltum to the amount of 40 tons was extracted from the remainder, 8½ tons of crude being consumed in the production of 1 ton of gum. In the tables of production in the preceding pages the amount and value is given for the material as it was first marketed, only 100 tons being included in the production of "crude."

TEXAS.

The "litho-carbon" property at Cline, in Uvalde County, was idle in 1896, and the company went into the hands of a receiver. The small product from the State in 1897, 65 short tons, was from the mines of the St. Jo Asphaltum Company, in Montague County.

COLORADO AND UTAH.

The production of asphaltum in these two States is combined in these reports for two reasons: First, in order to maintain the confidential nature of individual statements; second, because the gilsonite product of Colorado is from an extension eastward, into Rio Blanco County of that State, of the gilsonite deposits in the Uncompahgre Indian Reservation, Uinta County, Utah. Gilsonite is also mined in Wasatch County, Utah, and asphaltic limestone is produced in Utah County. The gilsonite deposits have been fully described in previous volumes of Mineral Resources and in a report by Mr. George H. Eldridge in Part I of the Seventeenth Annual Report of the Survey. In the report on asphaltum in Mineral Resources for 1896 a discussion of the chemistry of gilsonite by Dr. William C. Day was published. There is nothing of interest to add to the statements previously published except the figures of production in 1897, which show an increase of 530 tons in the amount over the output in 1896 and a decrease in value of $2,180. Lower prices for gilsonite are responsible for the decreased value.

Annual production of asphaltum, etc., in Utah since 1891.

Year.	Short tons.	Value.
1891	1,732	$82,100
1892	2,700	93,500
1893	a 3,200	90,000
1894	1,000	35,000
1895	700	22,500
1896	b 3,170	49,680
1897	b 3,700	47,500

a Including 100 tons of ozocerite.

b Including Colorado gilsonite.

IMPORTS.

The United States draws its chief supply of foreign asphaltum from the island of Trinidad, off the coast of Venezuela, the exports from Trinidad to the United States during the last four years averaging about the same as the domestic production. In addition to the Trinidad asphaltum we import some from Bermudez in Venezuela, Neufchatel and Val de Travers in Switzerland, Seysel in France, Germany, Cuba, and Mexico, and small amounts from other countries.

The following table shows the imports of crude asphaltum since 1867:

Crude asphaltum imported into the United States from 1867 to 1897.

Year ended—	Quantity.	Value.	Year ended—	Quantity.	Value.
	Long tons.			Long tons.	
June 30, 1867		$6,268	June 30, 1883	33,116	$149,999
1868	185	5,632	1884	36,078	145,571
1869	203	10,559	1885	18,407	88,087
1870	488	13,072	Dec. 31, 1886	32,565	108,528
1871	1,301	14,760	1887	30,808	95,735
1872	1,474	35,533	1888	36,494	84,045
1873	2,314	38,298	1889	61,952	138,163
1874	1,183	17,710	1890	73,861	223,368
1875	1,171	26,006	1891	102,433	299,350
1876	807	23,818	1892	120,255	336,868
1877	4,532	36,550	1893	74,774	196,314
1878	5,476	35,932	1894	102,505	313,680
1879	8,084	39,635	a 1895	79,557	210,556
1880	11,830	87,889	1896	96,192	304,596
1881	12,883	95,410	1897	115,528	392,770
1882	15,015	102,698			

a In addition to the crude asphaltum imported in 1895 there was some manufactured or refined gum asphaltum, valued at $36,664. In 1896 the value of the manufactured asphaltum imported was $77,449 and in 1897, $25,095. The quantity was not reported.

The following statement shows the amount and value of the asphaltum imported during the fiscal year ending June 30, 1897, with the countries from which it was exported. The amount credited to Italy is probably wholly or in part from Switzerland and shipped from an Italian seaport.

Imports of asphaltum during the fiscal year 1897, with the countries from which exported.

Country.	Long tons.	Value.
West Indies:		
British (Trinidad)	85,034	$198,786
Danish	400	2,000
Spanish (Cuba)	223	4,180
Italy (probably including Switzerland)	14,581	77,456
Venezuela (Bermudez)	13,807	75,943
Germany	6,896	25,986
France	861	3,327
Mexico	273	3,992
Turkey in Asia	31	3,439
Great Britain	11	309
United States of Colombia	3	130
Canada	2	6
Total	122,122	395,554

PRODUCTION IN OTHER COUNTRIES.

TRINIDAD.

The island of Trinidad, off the coast of Venezuela, South America, one of the British West Indian possessions, is, next to France, the largest producer of asphaltum in the world.[1] The deposits are operated by an American corporation under a concession from the British Government and, independently, from land not belonging to the Crown and which was acquired by purchase. The chief source of the supply is a lake of pitch filling the crater of an extinct volcano. This lake lies 138 feet above sea level and has an area of 114 acres. The supply is being constantly renewed by a flow of soft pitch into the center of the lake from a subterranean source, but not in proportion to the amount drawn from it. The shipments of lake pitch for the last nine years have averaged over 80,000 tons per year. The flow into the lake is at the rate of about 20,000 tons per year, so that the renewal of supply is less than one-fourth the amount taken out. The depth of the lake, however, is about 135 feet at the center, and considering the extent of the deposit, there need be little apprehension of the early exhaustion of asphaltum. The material from this lake is known as "lake pitch." Distinctive from this is what is known as "land pitch," the overflow in past times of pitch from the lake, and deposits of similar nature but different origin. The overflow pitch mingled with the soil, and while it, with the other land deposits, forms another source of supply, the amount of mineral matter it contains is greater than the lake pitch, and the latter is in consequence preferred.

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[1] The French asphaltum is in reality a bituminous limestone of which the bitumen contents average only about 14 per cent. Trinidad lake asphaltum, on the other hand, averages approximately 55 per cent bitumen. The product of France in 1896 was 233,624 short tons, of which the bitumen contents were about 33,700 short tons. The shipments of lake asphaltum in crude and crude equivalent from Trinidad in the same year amounted to 82,946 long tons, or 92,000 short tons, of which the bitumen contents, reckoned at 55 per cent, would be about 51,000 tons. It will be seen from this that while France produced the largest amount in crude, Trinidad is the leader of the world in the bitumen contents of its product.

Mr. O. E. Thurber, treasurer of the Trinidad Asphalt Company, of New York City, has kindly furnished the following statements showing the exports of Pitch Lake asphaltum from 1881 to 1897; also the exports of land asphaltum from 1886 to 1897, and the total exports of all asphaltum (stated in tons of crude or equivalent) from 1886 to 1897.

The shipments of Trinidad asphaltum to countries other than the United States and Europe have been so comparatively insignificant that they have been included under one caption.

Exports of Pitch Lake asphalt from Trinidad, 1881 to 1897, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total of exports in crude equivalent.
	Crude.	Dried.	Total equivalent in crude.	Crude.	Épuré and dried.	Total equivalent in crude.	Crude.	Épuré and dried.	Total equivalent in crude.	
	Tons	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1881	5,600	....	5,600	10,656	6,174	19,917	....	....	....	25,517
1882	12,710	....	12,710	24,712	12,007	42,722	....	....	....	55,432
1883	22,885	....	22,885	11,744	4,668	18,746	....	....	....	41,631
1884	17,885	....	17,885	15,910	6,561	25,751	....	....	....	43,636
1885	15,505	....	15,505	12,135	7,636	23,589	....	....	....	39,094
1886	22,225	....	22,225	5,130	5,394	13,221	....	....	....	35,446
1887	21,915	....	21,915	10,205	5,771	18,861	....	....	....	40,776
1888	24,321	....	24,321	8,445	8,248	20,817	....	....	....	45,138
1889	45,410	....	45,410	9,378	9,581	23,750	....	....	....	69,160
1890	39,907	....	39,907	11,755	9,951	26,681	668	....	[a] 668	67,256
1891	52,510	....	52,510	9,984	9,969	24,937	901	....	[a] 901	78,348
1892	70,806	....	70,806	11,596	9,458	25,783	1,076	....	[a] 1,076	97,665
1893	65,436	....	65,436	10,640	6,650	20,615	....	....	....	86,051
1894	71,860	....	71,860	8,967	9,413	23,086	....	....	....	94,946
1895	61,702	2,256	64,976	5,058	7,365	16,104	....	....	....	81,080
1896	60,637	....	60,637	8,320	8,052	20,391	....	1,300	[b] 1,918	82,946
1897	71,969	1,769	74,407	14,629	13,510	34,856	....	500	680	109,243

[a] Australia.

[b] Argentina and Mexico.

Exports of land asphalt from Trinidad, 1886 to 1897, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total of exports in crude equivalent.
	Crude.	Épuré.	Total equivalent in crude.	Crude.	Épuré	Total equivalent in crude.	Crude.	Épuré.	Total equivalent in crude.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1886	2,297	....	2,297	....	....	....	....	....	....	2,297
1887	1,195	2,100	4,345	220	....	220	....	....	....	4,565
1888	5,316	1,536	7,620	619	....	619	....	....	....	8,239
1889	10,490	2,052	13,568	....	....	....	833	....	*a* 833	14,401
1890	15,406	1,341	17,417	....	....	....	....	....	....	17,417
1891	20,507	7	20,517	139	....	139	40	....	*b* 40	20,696
1892	17,406	....	17,406	699	....	699	....	....	....	18,105
1893	3,450	....	3,450	2,432	1,862	5,225	110	178	*b* 377	9,052
1894	3,365	325	3,853	2,200	4,699	9,249	13	94	*b* 154	13,256
1895	4,445	199	4,744	1,770	2,368	5,322	....	169	*b* 254	10,320
1896	11,943	71	12,049	842	1,988	3,824	....	....	....	15,873
1897	19,243	....	19,243	293	700	1,343	415	178	682	21,268

a Australia. *b* Canada, Venezuela, and West Indies.

Total exports of all asphalt from Trinidad, 1886 to 1897, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1886	22,225	2,297	24,522	13,221	....	13,221	....	....	....	37,743
1887	21,915	4,345	26,260	18,861	220	19,081	....	....	....	45,341
1888	24,321	7,620	31,941	20,817	619	21,436	....	....	....	53,377
1889	45,410	13,568	58,978	23,750	....	23,750	....	833	833	83,561
1890	39,907	17,417	57,324	26,681	....	26,681	668	....	668	84,673
1891	52,510	20,517	73,027	24,937	139	25,076	901	40	941	99,044
1892	70,806	17,406	88,212	25,783	699	26,482	1,076	....	1,076	115,770
1893	65,436	3,450	68,886	20,615	5,225	25,840	....	377	377	95,103
1894	71,860	3,853	75,713	23,086	9,249	32,335	....	154	154	108,202
1895	64,976	4,744	69,720	16,104	5,322	21,426	....	254	254	91,400
1896	60,637	12,049	72,686	20,391	3,824	24,215	1,918	....	1,918	98,819
1897	74,407	19,243	93,650	34,856	1,343	36,199	680	682	1,362	130,511
Total	614,410	126,509	740,919	269,102	26,640	295,742	5,243	2,340	7,583	1,043,544

FRANCE.

The Statistique de l'Industrie Minérale gives the following as the output of asphaltum in France for five years, with the value of the product. For convenience and for comparison the quantities are expressed in metric tons and short tons, and the value both in francs and dollars:

Production of asphaltum in France from 1892 to 1896, inclusive

Year.	Production.		Value.	
	Metric tons.	Short tons.	Francs.	Dollars.
1892	224,000	246,848	1,678,000	323,854
1893	222,000	244,644	1,612,000	311,116
1894	231,000	254,562	1,758,000	339,294
1895	267,000	294,234	1,843,000	355,700
1896	212,000	233,624	1,180,000	227,740

It would appear from the foregoing statement that France is the leading country of the world in the production of asphaltum. It must be remembered, however, that the French product is entirely bituminous limestone, of which the bitumen contents are only 14 per cent. As explained in the footnote to the discussion of Trinidad production, the amount of bitumen in the Trinidad lake pitch product in 1896 was about 50 per cent more than that of the bitumen contents of the French output, although the French product of crude was more than double that of the lake and land pitch product of Trinidad combined.

GERMANY.

The production of asphaltum in the German Empire for the years 1886 to 1896, according to the official report Die Bergwerke, Salinen und Hütten im Deutschen Reich und Luxemburg, is shown in the following table. Metric tons are converted into short tons, and marks into dollars.

Production of asphaltum in Germany from 1886 to 1896.

Year.	Production.		Value.	
	Metric tons.	Short tons.	Marks.	Dollars.
1886	42,894	47,270	216,075	51,426
1887	34,483	38,000	186,125	44,298
1888	41,534	45,770	255,250	60,749
1889	43,496	47,933	325,246	77,408
1890	51,144	56,361	377,987	89,961
1891	49,150	54,163	375,712	89,419
1892	53,279	58,713	418,850	99,686
1893	47,238	52,056	356,982	84,962
1894	55,981	61,691	451,049	107,350
1895	59,563	65,638	454,424	108,153
1896	61,552	67,830	453,394	107,908

ITALY.

Following Germany in amount of asphaltum produced is Italy, the product for the four years 1893 to 1896, inclusive, being shown in the following table. It will be observed, however, that while the product of Italy in 1896 was about 25 per cent less than that of Germany, the value was about 60 per cent more.

Production of asphaltum in Italy from 1893 to 1896.

Year.	Production.		Value.	
	Metric tons.	Short tons.	Lire.	Dollars.
1893	25,980	28,630	565,800	109,200
1894	60,493	66,663	1,403,390	270,854
1895	46,713	51,478	1,023,751	197,584
1896	45,456	50,092	888,638	171,507

PRODUCTION OF OZOCERITE IN GALICIA.

The production of ozocerite, or mineral wax, in Galicia, Austria, for six years, as near as can be ascertained, has been as follows:

Production of ozocerite in Galicia from 1891 to 1896.

Year.	Metric tons.	Short tons.
1891	6,158.6	6,787.0
1892	5,637.6	6,213.0
1893	5,624.8	6,198.5
1894	6,743.1	7,431.0
1895	6,644.5	7,322.0
1896	7,210.0	7,945.0

SUMMARY OF PRODUCTION OF ASPHALTUM SINCE 1890.

The following table exhibits, in convenient form for comparison, the production of asphaltum in the principal producing countries, for such years as it can be obtained since 1890. In addition to the production given in this table, Russia is credited with an output of 16,640 metric tons in 1893 and 16,067 metric tons in 1894. Mexico is said to have produced some asphaltum in 1894–95, having a value of $3,751, but the quantity was not stated. The United States imported 273 long tons from Mexico in the fiscal year 1897. We also imported 13,807 tons from Venezuela, 400 tons from the Danish West Indies, 223 tons from

Cuba, and small amounts from Great Britain, Canada, Colombia, and Turkey in Asia, but no statistics of the total production in these countries are available. The quantities in the following table have been reduced to short tons of 2,000 pounds:

Production of asphaltum in principal producing countries since 1890.

Year.	United States.		Trinidad.		Germany.	
	Product.	Value.	Product.	Value.	Product	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1890........	40, 841	$190, 416	94, 834	$254, 019	59, 361	$89, 961
1891........	45, 054	242, 264	110, 929	297, 132	54, 163	89, 419
1892........	87, 680	445, 375	129, 438	347, 310	58, 713	99, 686
1893........	47, 779	372, 232	106, 515	285, 309	52, 056	84, 962
1894........	60, 570	353, 400	121, 186	324, 606	61, 691	107, 350
1895........	68, 163	348, 281	102, 368	274, 200	65, 638	108, 153
1896........	80, 503	577, 563	110, 667	296, 457	67, 830	107, 908
1897........	75, 945	664, 632	146, 172	292, 344	....	....

Year.	France.		Italy.		Spain.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1890........	198, 934	$335, 092	49, 728	$232, 351	47	$94
1891........	278, 316	402, 631	31, 054	131, 028	274	505
1892........	246, 848	323, 854	38, 107	162, 308	554	1, 014
1893........	244, 644	311, 116	28, 630	109, 200	904	1, 235
1894........	254, 562	339, 294	66, 663	270, 854	1, 085	1, 939
1895........	294, 234	355, 700	51, 478	197, 584	870	1, 525
1896........	233, 624	227, 740	50, 092	171, 507	1, 231	2, 156
1897........	....	....	....	....	....	....

THE PRODUCTION OF AN ASPHALT RESEMBLING GILSONITE BY THE DISTILLATION OF A MIXTURE OF FISH AND WOOD.[1]

By William C. Day.

A few years since the writer undertook a rather detailed experimental study of the variety of asphalt known as gilsonite,[2] which is mined for commercial use in Utah. Gilsonite is a black, glistening, brittle material, yielding a dark-brown powder when finely pulverized. It fuses readily, becoming a liquid, which begins to boil at a temperature above the limit of a mercury thermometer.

It is entirely soluble in carbon bisulphide, not entirely soluble in ordinary ether, partially soluble in absolute alcohol, petroleum ether, glacial acetic acid, and chloroform, imparting to these solvents a yellowish to red color with green fluorescence. Besides carbon and hydrogen it contains sulphur, nitrogen, a trace of oxygen, and one-tenth of 1 per cent of ash.

Among the various products which were obtained by distilling gilsonite may be mentioned as of interest in this connection certain nitrogenous bases extracted from the distillates by the action of dilute acid and precipitated therefrom by alkalies. These bodies have an odor like that of the pyridine and quinoline series. Such substances were first obtained from bitumen by Prof. S. F. Peckham, who noticed them in distillates from California petroleum, and later by myself from an asphalt occurring in Coos County, Oreg., and also in the product which forms the subject of this paper.

As a result of considerable experimental work in the last few years with asphalts from a variety of sources in the United States, together with a study of the literature pertaining to the question of the origin of the bitumens from both the geological and the chemical standpoints, I became impressed with the belief that the solid and also some of the higher boiling liquid bitumens have been formed in the earth by the distillation of mixed animal and vegetable material together with steam at high temperatures, but at pressures which may or may not have been high. Petroleum distillates have been obtained by Warren, and later by Engler, from fish oil, and still more recently by Sadtler from linseed oil. In addition to liquid distillates, paraffin has also been obtained by these investigators. No mention, however, of an analogous production of asphalts, so far as I am aware, has been made.

To test the correctness of the belief already expressed the following experiments were made:

Into a cylindrical iron retort were introduced a number of fresh herring, a quantity of pine sawdust, and a number of small pieces of fat pine wood. The retort was connected by plaster-of-paris joint with a short glass tube, and this with a gas pipe 4 feet long, the latter being placed in an ordinary combustion furnace. The other end of the pipe was connected with a Liebig's cold-water condenser. After charging and closing the retort it was heated by means of gas stoves, which together with the retort were surrounded with loose brick to prevent loss of heat. The heating of the retort was regulated by the rapidity with which vapors were evolved, an increase of heat being necessary toward the end of the distillation. The gas pipe was simultaneously heated to bright redness by the combustion furnace. The pressure was that of the atmosphere. During the progress of the distillation, water and oil, together with a white, smoke flowed from the condenser into the receiver. The oil obtained was lighter than water, of bad odor, and very dark red in color. At the end of the gas pipe next to the retort carbon separated and on one occasion nearly choked the pipe. Only once was an oil heavier than water obtained, and this was small in amount.

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[1] This is an abstract of a paper read before the American Philosophical Society at the meeting held May 20, 1898, and published in the Proceedings of the society.

[2] Jour. Franklin Inst., Vol. CXL, No. 3, September, 1895, pp. 221-237.

The condensed oil was separated from the water on which it floated and finally completely dried over chloride of calcium. It was then placed in a distilling bulb provided with thermometer and distilled, using a straight glass tube as an air condenser. Boiling began at about 100° C., but the mercury soon rose to 120°.

The distillate between these limits consisted of a lemon-yellow mobile oil together with a few drops of water.

At 120° the receiver was changed and another fraction darker in color and less mobile was obtained, while the mercury rose to 180°. The third fraction was collected between the limits 180° and 245°. The fourth was obtained between 245° and 315°. This fraction showed a pronounced greenish fluorescence, the color by transmitted light being dark red. At 340° the receiver was again changed, the thermometer removed, and the distillation continued until the temperature was (at a guess) about 425° C. At this point the distilling bulb cracked and the operation was stopped. On cooling, the contents of the bulb became a black brittle solid, showing a very pronounced resemblance to gilsonite in every way. The following are its properties: Black, glistening, color becoming brown on pulverizing, and slightly darker than gilsonite; fracture conchoidal, entirely soluble in carbon bisulphide; ether dissolves 90.6 per cent; alcohol, 66.3 per cent; petroleum ether, 61.1 per cent. All these solutions show greenish fluorescence, while the color by transmitted light varies from yellow to reddish.

As already stated, the distilling bulb cracked before it had been decided to stop the distillation, and the solid product being slightly sticky to the touch, a second portion of oil was distilled, collecting the same fractions as before, but continuing the heating longer. This time a solid so like gilsonite was obtained that it was difficult to tell which was which. A combustion of the first sample gave carbon 87.5

per cent and hydrogen 7.7 per cent. A combustion of the second sample gave carbon 88.9 per cent and hydrogen 6.7 per cent. The figures for Utah gilsonite are 88.3 for carbon and 9.9 for hydrogen. At the time (three years since) the analysis of gilsonite was made nitrogen was not determined; recently I have determined the nitrogen, and found it to be 1.96 per cent. Since the carbon, hydrogen, and sulphur figures added up to 99.5, one or all of the three must have been high, and I am inclined to think that it was the hydrogen, since I can not now be sure that the gilsonite sample was entirely dry.

The agreement in properties and composition between the gilsonite and this distillation product is much more perfect than it would have been reasonable to expect at the outset of the experiments, particularly when it is remembered that both are doubtless mixtures in themselves, and that certainly on distillation they yield highly complicated mixtures of hydrocarbons.

The distillation of fish alone, i. e., without mixture with wood, was found to give nothing like gilsonite, and the distillation products were totally different in every way from those obtained from the mixture of fish and wood.

As the product under discussion was obtained only a few days ago[1] there has not been time to carry the investigation further, but enough has been done to show how a solid asphaltum may have been formed in nature and to afford a rather satisfactory demonstration of the correctness of views entertained by a number of scientists who have based their opinions largely on geological evidence and the study of natural occurrences.

This brief paper is, of course, only preliminary to one which should consider the literature of the subject more in detail, and which may, I trust, throw some light on a few of the many problems which naturally suggest themselves.

The work will be continued as rapidly as my rather limited time and facilities for such study will permit. In conclusion, I take pleasure in expressing my obligations to my assistant, Mr. Eugene Leamy, for his very intelligent and effective aid in carrying on the experimental work.

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[1] These experiments were completed about June 1, 1898.

STONE.

By William C. Day.

INTRODUCTION.

The replies to inquiries addressed to the individual quarrymen of the United States have been exceptionally complete and full, and it is upon the information thus gained at first hand by direct correspondence with the producers that all important conclusions in the report are based. Unusual promptness in replying has also been shown. Some quarrymen have even sent in the usual reports unsolicited, thus showing a gratifying spirit of cooperation in the difficult task of publishing promptly the data secured. The importance of prompt replies can not be overestimated in work of this kind, and it is hoped that in future the few producers who need second, and sometimes even third, reminders, will, in the interest of prompt publication, make an effort to avoid unnecessary delay in mailing their returns.

ACKNOWLEDGMENTS.

While the individual returns from quarrymen constitute the most important source of information used in this report, the following technical journals have been consulted, and the value of information obtained from them is hereby acknowledged: Stone, of Chicago; The Monumental News, of Chicago; The Granite Cutters' Journal, of Baltimore; The Stone Trade News, of Concord, New Hampshire; The Mining Industry and Review, of Denver, Colorado; The American Slate Trade Journal, of Bangor, Pennsylvania, and The Journal of the Franklin Institute, of Philadelphia.

In addition to these there are many other technical papers which have been of occasional assistance. Special acknowledgments for use of publications in the above and other journals are made in the proper places in this report.

VALUE OF STONE PRODUCED IN 1896 AND 1897.

The following table shows the value of the different kinds of stone produced in the United States during the years 1896 and 1897:

Value of different kinds of stone produced in the United States during the years 1896 and 1897.

Kind.	1896.	1897.
Granite	$7,944,994	$8,905,075
Marble	2,859,136	3,870,584
Slate	2,746,205	3,524,614
Sandstone	4,023,199	4,065,445
Limestone	13,022,637	14,822,661
Bluestone	*a* 750,000	*a* 900,000
Total	31,346,171	36,088,379

a Estimated.

This table shows that the production of all the various kinds of stone has undergone a substantial increase. The reason for this is unquestionably that the financial conditions in general have improved, and a return toward prosperity is emphatically indicated. This improvement is not characteristic of all producing regions alike, since in some of them the wave has not as yet made its appearance; but, as in times of panic or depression, some industries feel the effects some time after they have been disastrous in others, these are also likely to be behind when recovery is again inaugurated.

VALUE OF STONE PRODUCT IN 1897, BY STATES.

The following table shows the value of the various kinds of stone produced in 1897, by States:

Value of various kinds of stone produced in 1897, by States.

State.	Granite.	Sandstone.	Slate.	Marble.	Limestone.	Total.
Alabama		$3,000			$221,811	$224,811
Arizona		15,000			11,522	26,522
Arkansas		3,161			44,222	47,383
California	$167,518	4,035	$7,000	$48,690	308,925	536,168
Colorado	44,284	60,847		99,600	79,256	283,987
Connecticut	616,215	364,604			178,410	1,159,229
Delaware	272,469					272,469
Florida					18,889	18,889
Georgia	436,000			598,076	32,000	1,066,076
Idaho	1,900			5,000	15,538	22,438
Illinois		14,250			1,483,157	1,497,407

Value of various kinds of stone produced in 1897, by States—Continued.

State.	Granite.	Sandstone.	Slate.	Marble.	Limestone.	Total.
Indiana		$35, 561			$2, 012, 608	$2, 048, 169
Iowa		14, 771			480, 572	495, 343
Kansas		20, 953			208, 889	229, 842
Kentucky		40, 000			40, 815	80, 815
Louisiana		8, 000				8, 000
Maine	$1, 115, 327		$201, 117		742, 877	2, 059, 321
Maryland	247, 948		53, 939	$130, 000	199, 365	631, 252
Massachusetts	1, 736, 069	194, 684		79, 721	126, 508	2, 136, 982
Michigan		171, 127			215, 177	386, 304
Minnesota	92, 412	158, 057	1, 500		236, 397	488, 366
Missouri	97, 857	57, 583			1, 018, 202	1, 173, 642
Montana		25, 644			37, 300	62, 944
Nebraska					42, 359	42, 359
Nevada	3, 050					3, 050
New Hampshire	641, 691					641, 691
New Jersey	561, 782	190, 976	775		141, 646	895, 179
New York	422, 216	544, 514	53, 799	354, 631	1, 697, 780	3, 072, 940
North Carolina	59, 236	11, 500				70, 736
Ohio		1, 600, 058			1, 486, 550	3, 086, 608
Oregon	1, 125					1, 125
Pennsylvania	349, 947	380, 813	2, 365, 299	62, 683	2, 327, 870	5, 486, 612
Rhode Island	629, 564				11, 555	641, 119
South Carolina	37, 820				30, 000	67, 820
South Dakota	68, 961				3, 895	72, 856
Tennessee				441, 954	113, 774	555, 728
Texas	3, 500	30, 030			57, 258	90, 788
Utah	3, 854	7, 907			9, 250	21, 011
Vermont	1, 074, 300		695, 815	2, 050, 229	165, 657	3, 986, 001
Virginia	88, 096		145, 370		192, 972	426, 438
Washington	5, 800	16, 187			126, 877	148, 864
West Virginia		47, 288			61, 546	108, 834
Wisconsin	126, 134	33, 620			641, 232	800, 986
Wyoming		11, 275				11, 275
Total	8, 905, 075	4, 065, 445	3, 524, 614	3, 870, 584	14, 822, 661	35, 188, 379
Bluestone [a]						900, 000
Grand total						36, 088, 379

[a] Estimated.

GRANITE.

The following table shows the value of the granite output by States:

Value of granite product, by States, in 1897.

State.	Value.	State.	Value.
California	$167,518	New York	$422,216
Colorado	44,284	North Carolina	59,236
Connecticut	616,215	Oregon	1,125
Delaware	272,469	Pennsylvania	349,947
Georgia	436,000	Rhode Island	629,564
Idaho	1,900	South Carolina	37,820
Maine	1,115,327	South Dakota	68,961
Maryland	247,948	Texas	3,500
Massachusetts	1,736,069	Utah	3,854
Minnesota	92,412	Vermont	1,074,300
Missouri	97,857	Virginia	88,096
Nevada	3,050	Washington	5,800
New Hampshire	641,691	Wisconsin	126,134
New Jersey	561,782	Total	8,905,075

The table of granite production by States shows a gain in total output for the year 1897 of $960,081 over 1896. This advance is greater than was generally expected at the beginning of the year. Increase is characteristic of nearly all of the productive States, but is particularly striking in the case of Vermont, which has reached the highest figure ever attained in that State. This is due to activity at Barre. Quite large gains also are evident for Georgia, New Hampshire, New Jersey, New York, and Pennsylvania.

The table on the next page shows the purposes for which the granite was sold by the quarrymen. The column headed "Rough" shows how much stone was sold in rough condition without any special squaring up or dressing. The purposes which such stone ultimately served is a matter of question, as it was disposed of by the quarrymen to builders, monument and tombstone cutters, and to others for uses which could not be ascertained from the quarrymen. In spite of the difficulty thus indicated, however, the table will probably be found of interest in showing, for example, just how far the quarrymen go in preparing their product for immediate consumption without the intervention of others.

Value of granite, by States and uses, in 1897.

State.	Rough.	Building purposes.	Monumental and cemetery purposes.	Paving.	Road-making or macadamizing.	Other purposes.	Total.
California	$39,351	$35,508	$37,525	$32,264	$22,000	$870	$167,518
Colorado	7,825	34,175	2,284				44,284
Connecticut	248,955	148,414	94,271	76,760	34,460	*a* 13,355	616,215
Delaware	246,751	16,171		7,073		*a* 2,474	272,469
Georgia	40,288	56,366	15,083	295,005	2,318	*a* 26,940	436,000
Idaho	1,900						1,900
Maine	228,663	505,826	56,576	172,637		*b* 151,625	1,115,327
Maryland	146,213	52,048	2,700	3,328	41,999	1,660	247,948
Massachusetts	539,163	678,616	229,346	243,750	4,900	*c* 40,294	1,736,069
Minnesota	16,826	52,668	22,918				92,412
Missouri	25,428	3,222	4,181	47,646	17,380		97,857
Nevada	1,300	750	1,000				3,050
New Hampshire	161,190	217,486	214,803	26,177		*d* 22,035	641,691
New Jersey	700	28,501	1,060	24,006	477,515	*e* 30,000	561,782
New York	12,140	131,626	10,450	26,900	241,100		422,216
North Carolina	25,032	32,794	1,250			160	59,236
Oregon	1,125						1,125
Pennsylvania	64,638	30,316		11,708	110,065	*f* 133,220	349,947
Rhode Island	42,706	209,355	316,585	51,646	3,000	*g* 6,272	629,564
South Carolina	20,692		12,376	4,643	109		37,820
South Dakota	11,131	11,000	5,300	40,030	1,500		68,961
Texas	2,500		1,000				3,500
Utah	558	400	2,896				3,854
Vermont	430,121	283,167	341,034	16,770	3,208		1,074,300
Virginia	25,234	28,827	13,788	20,247			88,096
Washington	3,600	1,200		1,000			5,800
Wisconsin	19,001	7,200	28,076	38,827	32,313	717	126,134
Total	2,363,031	2,565,636	1,414,502	1,140,417	991,867	429,622	8,905,075

a All used for curbing.
b $80,000 dressed for bridge work and $71,625 for curbing.
c $25,126 for curbing.
d $15,525 for curbing.
e For bridge work.
f $130,020 for bridge work.
g $5,150 for curbing.

The following table shows the output of paving blocks in the years 1896 and 1897. A decrease is evident; the paving block industry is suffering from competition with various kinds of smoother and less noise-producing materials, such as asphalt and brick:

Value of granite paving blocks made in 1896 and 1897, by States.

State.	1896.	1897.
California	$73, 390	$32, 264
Connecticut	32, 592	76, 760
Delaware	17, 074	7, 073
Georgia	94, 390	295, 005
Maine	344, 101	172, 637
Maryland	33, 933	3, 328
Massachusetts	324, 784	243, 750
Missouri	27, 911	47, 646
New Hampshire	26, 353	26, 177
New Jersey	14, 847	24, 006
New York	24, 389	26, 900
North Carolina	1, 554	....
Oregon	210	....
Pennsylvania	65, 580	11, 708
Rhode Island	50, 851	51, 646
South Carolina	4, 644	4, 643
South Dakota	28, 326	40, 030
Vermont	30, 990	16, 770
Virginia	10, 129	20, 247
Washington	....	1, 000
Wisconsin	25, 688	38, 827
Total	1, 231, 736	1, 140, 417

VALUE OF THE GRANITE PRODUCT, BY STATES, FROM 1890 TO 1897.

The following table gives the value of the granite output, by States, for the years 1890 to 1897:

State.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Arkansas	(a)	$65,000	$40,000	....	$28,100	....	....	....
California	$1,329,018	1,300,000	1,000,000	$531,322	307,000	$348,806	$215,883	$167,518
Colorado	314,673	300,000	100,000	77,182	49,302	35,000	36,517	44,284
Connecticut	1,061,202	1,167,000	700,000	652,459	504,390	779,361	794,325	616,215
Delaware	211,194	210,000	250,000	215,964	173,805	73,138	67,775	272,469
Georgia	752,481	790,000	700,000	476,387	511,804	508,481	274,734	436,000
Idaho	....	....	....	....	....	14,560	3,037	1,900
Maine	2,225,839	2,200,000	2,300,000	1,274,954	1,551,036	1,400,000	1,195,491	1,115,327
Maryland	447,189	450,000	450,000	260,855	308,966	276,020	251,108	247,948
Massachusetts	2,503,503	2,600,000	2,200,000	1,631,204	1,994,830	1,918,894	1,656,973	1,736,069
Minnesota	356,782	....	360,000	270,296	153,936	148,596	155,297	92,412
Missouri	500,642	400,000	325,000	388,803	98,757	128,987	107,710	97,857
Montana	(a)	51,000	36,000	1,000	5,800	....	....	....
Nevada	(a)	....	....	3,000	1,600	3,200	1,250	3,050
New Hampshire	727,531	750,000	725,000	442,424	724,702	480,000	497,966	641,691
New Jersey	425,673	400,000	400,000	373,147	310,965	151,343	204,323	561,782
New York	222,773	225,000	200,000	181,449	140,618	68,474	161,167	422,216
North Carolina	146,627	....	150,000	122,707	108,993	75,000	40,017	59,236
Oregon	44,150	3,000	6,000	11,255	4,993	1,728	2,449	1,125
Pennsylvania	623,252	575,000	550,000	206,493	600,000	300,000	159,317	349,947
Rhode Island	931,216	750,000	600,000	509,799	1,211,439	968,473	746,277	629,564
South Carolina	47,614	50,000	60,000	95,443	45,899	22,083	55,320	37,820
South Dakota	304,673	100,000	50,000	27,828	8,806	33,279	199,977	68,961
Texas	22,550	75,000	50,000	38,991	....	....	....	3,500
Utah	8,700	....	15,000	590	....	....	886	3,854
Vermont	581,870	700,000	675,000	778,459	893,956	1,007,718	895,516	1,074,200
Virginia	332,548	300,000	300,000	103,703	123,361	70,426	95,040	88,096
Washington	(a)	....	....	....	....	....	....	5,800
Wisconsin	266,095	406,000	400,000	133,220	166,098	80,761	126,639	126,134
Total	14,464,095	13,867,000	12,642,000	8,808,934	10,029,156	8,894,328	7,944,994	8,905,075

a Granite valued at $76,000 was produced in Arkansas, Montana, Nevada, and Washington together, and this amount is included in the total.

THE GRANITE INDUSTRY IN INDIVIDUAL STATES.

CALIFORNIA.

The output of granite in 1897 amounted in value to $167,518. The figure for 1896 was $215,883, so that there has been a large decline in production. Comparatively few paving blocks were made in 1897, since the overproduction of a few years previous was ample to supply the demand. Some blocks were sold below cost. Many of these had been lying by the railroad sidings ready for shipment for several years. Much of the stone used for paving and macadamizing is basalt.

The following is a statement of results obtained at the Watertown Arsenal on granite from the Rocky Point Granite Works at Exeter, Tulare County:

Tests of granite from Exeter, Tulare County, California.

[Shearing test.]

Number.	Shearing dimensions.	Shearing area.	Transverse fracture developed.	Shearing strength.	
				Total.	Per square inch.
	Inches.	*Square inches.*	*Pounds.*	*Pounds.*	*Pounds.*
302	4.04 × 6 × 2	48.48	42,500	117,300	2,419

Analysis of granite from Exeter, California.

	Per cent.
Silica, SiO_2	75.35
Oxide of iron, Fe_2O_3	3.94
Oxide of aluminum, Al_2O_3	13.69
Oxide of calcium, CaO	2.97
Oxide of magnesium, MgO	.06
Oxide of sodium, Na_2O	1.14
Oxide of potassium, K_2O	2.85
Total	100.00

Transverse test of Exeter (California) granite.

[Ends supported 20 inches apart, loaded at the middle.]

Number.	Description.	Dimensions.		Ultimate strength.	
		Breadth.	Depth.	Total.	Modulus of rupture.
		Inches.	*Inches.*	*Pounds.*	*Pounds.*
432	Light colored	4.03	6.07	9,170	1,853

Coefficient of expansion = 0.00000461 per inch.

The following is a statement of mechanical tests made at the Watertown Arsenal by Maj. J. W. Reilly on the granite quarried by the Rocklin Granite Company.

Tests of granite from Rocklin, California.

[Tests by compression, granite cubes, pyramidal fractures.]

No. of test.	Marks.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
		Height.	Compressed surface.				Total.	Per sq. inch.
		Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
9819	No. 1	3.96	3.96	3.96	15.68	332,000	342,100	21,817
9820	No. 2	3.94	3.97	3.96	15.72	329,000	340,900	21,686
9821	No. 3	3.96	3.96	3.97	15.72	271,000	311,400	19,809

COLORADO.

The value of granite produced in 1897 was $44,284. This is a slight increase over 1896.

CONNECTICUT.

Production fell off from a valuation of $794,325 in 1896 to $616,215 in 1897. This decline was due to the fact that very much less breakwater stone was quarried for Government use in 1897 than in the preceding year. But for the decline in this item production would have increased, as business was better in a number of the producing localities in the State.

The following data relative to granite quarried by Mr. Henry Gardiner, at Millstone, are submitted. The tests were made by General Gillmore in 1875.

Crushing strength determined with 2-inch cubes. Total strength, 75,000 pounds. This is equal to 18,750 pounds per square inch. Specific gravity, 2.706.

The following tests of crushing strength of granite quarried by the Booth Brothers and Hurricane Isle Granite Company at its quarries at Waterford, Connecticut, were made by Mr. Ira H. Woolson, E. M., of Columbia University, New York City:

Crushing strength of granite from Waterford, Connecticut.

[Two-inch cubes tested.]

Number.	Size.	Area.	First crack.	Crushed at.	Maximum per square inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1575	2.1 high × 2.00 × 1.98	3.96	65,000	93,100	23,510
1576	2.008 high × 2.03 × 2.01 ...	4.08	92,000	97,600	23,921

The following analysis of the same granite was made by Messrs. Ricketts and Banks, of New York City:

Analysis of granite from Waterford, Connecticut.

	Per cent.
Silica, SiO_2	68.11
Alumina, Al_2O_3	14.28
Ferrous oxide, FeO	2.63
Lime, CaO	1.86
Magnesia, MgO	.68
Sulphur	.34
Oxide of potassium, K_2O	5.46
Oxide of sodium, Na_2O	6.57
Total	99.93

DELAWARE.

A large increase in production was realized in 1897, in this State; that is, from $67,775, in 1896, to $272,469, in 1897. This is very easily explained for the reason that a large quantity of breakwater stone for Government use was quarried in 1897.

The following tests and analysis were made by Messrs. Booth, Garrett, and Blair, of Philadelphia, on the gneiss quarried by the Brandywine Granite Company, of Wilmington, Delaware:

Analysis and tests of granite from Wilmington, Delaware.

	Per cent.
Loss on ignition, i. e., organic matter and moisture	0.30
Silica, SiO_2	67.98
Alumina, Al_2O_3	16.14
Ferrous oxide, FeO	4.39
Lime, CaO	5.89
Magnesia, MgO	.53
Oxide of sodium, Na_2O	4.32
Oxide of potassium, K_2O	.45
Total	100.00

Specific gravity = 2.77.

Crushing test: On natural bed No. 1, 2 by 2 inches equals 4 square inches, at 100,300 pounds, equals 25,075 pounds per square inch. Across natural bed No. 2, 2 by 2 inches equals 4 square inches, at 99,000 pounds, equals 24,750 pounds per square inch.

Average: 24,913 pounds per square inch.

Absorption of water: Weight after drying twenty-four hours at 212° F., 1.20 pounds. Weight after immersing twenty-four hours in distilled water, 1.20 pounds. Water absorbed, 0.0 pounds or 0.0 per cent.

GEORGIA.

Production increased from $274,734 in 1896 to $436,000 in 1897. Conditions were quite substantially improved.

A crushing-strength test made at the Washington (D. C.) Navy-Yard on six 2-inch cubes of granite quarried by Mr. John Bradley at Lithonia, Georgia, gave a mean of 85,467 pounds, or 21,367 pounds to the square inch.

IDAHO.

Very little was accomplished in granite production during the year.

MAINE.

A slight decrease in production characterized the year 1897; the total value of output in 1896 was $1,195,491; in 1897, $1,115,327. Some of the individual reports indicate better prospects for 1898.

The following analysis of the granite quarried by the Blue Hill Granite Company, of Blue Hill, Hancock County, Maine, was made by Mr. Henry J. Williams, chemist, of Boston, Massachusetts.

Analysis of Blue Hill, Maine, granite.

	Per cent.
Water, H_2O	0.27
Silica, SiO_2	74.64
Ferric oxide, Fe_2O_3	1.56
Alumina, Al_2O_3	14.90
Lime, CaO	.39
Magnesia, MgO	Trace.
Potassium oxide, K_2O	6.88
Sodium oxide, Na_2O	.41
Total	99.05

On the basis of this chemical analysis the chemist estimates the mineralogical composition as follows:

Composition of granite from Blue Hill, Maine.

	Per cent.
Mica	35
Feldspar	10
Quartz	55
Total	100

The following tests of granite quarried by Messrs. S. L. Treat & Son at their quarries at Millbridge, Maine, were made at the Watertown Arsenal under the direction of Maj. J. W. Reilly:

Tests of granite from Millbridge, Maine.

COMPRESSIVE ELASTIC PROPERTIES.

[Sectional area, 4.″12 × 6.″09 = 25.09 square inches. Gauged length, 20″.]

Applied loads.		In gauged length.		Remarks.
Total.	Per square inch.	Compression.	Set.	
Pounds.	*Pounds.*	*Inch.*	*Inch.*	
2,509	100	0.	0.	Initial load.
25,090	1,000	.0023		
50,180	2,000	.0047		
75,270	3,000	.0069		
100,360	4,000	.0089		Modulus of elasticity E = 9,800,000.
125,450	5,000	.0108		
100,360	4,000	.0089		
75,270	3,000	.0069		
50,180	2,000	.0050		
25,090	1,000	.0030		
2,509	100		.0008	
25,090	1,000	.0027		
50,180	2,000	.0045		
75,270	3,000	.0067		
100,360	4,000	.0088		
125,450	5,000	.0108		
100,360	4,000	.0089		
75,270	3,000	.0069		
50,180	2,000	.0049		
25,090	1,000	.0030		
2,509	100		.0008	

Tests of granite from Millbridge, Maine—Continued.

LATERAL EXPANSION.

Gauged length, 5.5″.

Applied loads.		In gauged length.		Remarks.
Total.	Per square inch.	Compression.	Set.	
Pounds.	*Pounds.*	*Inch.*	*Inch.*	
2,509	100	0.	0.	Initial load.
125,450	5,000	.0005	....	
2,509	100	....	.0001	Ratio of lateral expansion to longitudinal compression, 1 to 6.8.
125,450	5,000	.0005	....	
2,509	100	....	.0001	

This specimen used in transverse test No. 391.

SHEARING TEST.

[Light-colored stone.]

No. of test.	Shearing dimensions.	Shearing area.	Transverse fracture developed on tension side.	Shearing strength.		Surfaces sheared.
				Total.	Per square inch.	
	Inches.	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*	
309	4.02×5.99×2	48.16	43,800	135,800	2,820	One.

TRANSVERSE TESTS.

[Ends supported 20″ apart; loaded over length of 1″ at middle.]

No. of test.	Dimensions.		Ultimate strength.		Remarks.
	Breadth.	Depth.	Total.	Modulus of rupture R.	
	Inches.	*Inches.*	*Pounds.*	*Pounds.*	
391	4.12	6.09	10,540	2,069	
424	4.13	6.08	10,320	2,027	Had been previously exposed to hot and cold water baths during observations made on the coefficient of expansion by heat.

Coefficient of expansion .00000400 between 32° and 212° F.

The following tests of granite quarried by the Maine and New Hampshire Granite Company at their quarries at North Jay, Maine, were made at the Watertown Arsenal under the direction of Maj. F. W. Parker:

Test by compression of red granite from North Jay, Maine.

Test number.	Height.	Dimension compressed surface.		Sectional area.	First crack.	Ultimate total.	Strength per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
4541	3.02	3.00	3.00	9.00	196,800	201,300	22,367

Pyramidal fracture.

Test of white granite from North Jay, Maine.

[Compressed surface faced with plaster of paris.]

Sectional area, 6.18 inches × 6.00 inches = 37.08 square inches.
First crack at 583,000 pounds = 15,722 pounds per square inch.
Ultimate strength, 604,800 pounds = 16,310 pounds per square inch.
Pyramidal fracture.

The following report on the same granite was made by Prof. J. E. Wolff, of Cambridge, Massachusetts:

REPORT ON STONE FROM NORTH JAY, MAINE.

The analysis of this stone is based on two pieces 4×2×1½ inches, of which one was used for chemical analysis, the other for the preparation of thin slices.

The rock as seen by the eye is an even-grained, white granite composed of white feldspar, quartz, plates of black mica (biotite), and white mica (muscovite), with a very rare small grain of red garnet. It has a perfectly even, massive structure without any visible line of structure or weakness. The scientific name of the rock is biotite-muscovite-granite.

Thin transparent slices of the rock were prepared and studied under the microscope, by which even the smallest impurities can be detected and the constituent minerals determined and the degree of freshness, absence or presence of cracks, etc., can be seen.

The following minerals compose the rock:

Composition of rock from North Jay, Maine.

Potash feldspar (orthoclase).
Potash feldspar (microcline).
Soda (lime) feldspar (plagioclase).
Dark mica (biotite).
Light mica (muscovite).
Quartz.

Garnet and some small accessory minerals always present in granite. All these minerals are entirely fresh, and even the feldspar, which in many good granites is clouded or whitish, owing to partial decomposition, is here entirely clear. The biotite is fresh and so is the garnet. There is hardly any magnetite in the rock and no carbonate and no pyrite, so far as could be seen. The grains are free from fractures which could possibly allow the moisture and frost to enter the rock and cause disintegration. A careful search was made for pyrite in the piece of rock and in the thin slice, but it was not found. The following analysis of the rock has been made by Mr. E. T. Rogers:

Analysis of granite from North Jay, Maine.

	Per cent.
Silica, SiO_2	71.54
Titanic oxide, TiO_2, and iron peroxide, Fe_2O_3	.84
Alumina, Al_2O_3	14.24
Ferric oxide, Fe_2O_3	.74
Ferrous oxide, FeO	1.18
Lime, CaO	.98
Magnesia, MgO	.34
Soda, Na_2O	3.39
Potash, K_2O	4.73
Water (at red heat)	.61
Sulphur, S	Trace.
Carbon dioxide, Co_2	Trace.
Total	98.59

This is the proper proportion for an average fresh granite of this mineral composition, showing a per cent of ferric iron below the average and of water below the average. As the water in granite is principally due to the decay of the feldspar and is an index of this decay, this low per cent bears out the previous statement as to the freshness of the feldspar. The ferric iron is an index to the amount of magnetic iron oxide present in the rock, and shows a very small amount. As this sometimes produces spots in time, its absence is very desirable. The trace of sulphur may be due to pyrites, but it has not been possible to detect any, and if present it must be of little importance. The cause of decay in this class of granites lies generally in the feldspar or in minute fissures penetrating the minerals. Easily soluble substances like carbonate of lime are bad, and grains of pyrites cause iron stains.

So far as this kind of an examination can go, this rock is exceptionally free from visible defects, and the microscopic and chemical analyses confirm this.

MARYLAND.

The output in 1897 differs very little from that in the preceding year. The figures for the two years were $251,108 for 1896, and $247,948 for 1897. Although there was a slight decrease, producers speak much more cheerfully than in 1896.

MASSACHUSETTS.

This State is now, and always has been, the leading State of the country in granite production. Production increased from $1,656,973 in 1896 to $1,736,069 in 1897.

The decline in the production of paving blocks, which has been going on all over the country during the past few years, has been keenly felt in Massachusetts. This decline is due in some degree to hard times, but it is becoming evident that much of it is also due to competition with other paving materials, particularly brick and asphalt. These latter materials are preferred where traffic is not too heavy because of less noise and less expense in cleaning.

On the whole, conditions are decidedly better in Massachusetts now than they were a few years ago, and prospects for the future are much more encouraging, although it may take a year or two yet to get back to the status of 1891.

The following test of crushing strength was made at the Watertown Arsenal under the direction of Maj. F. H. Parker. The stone tested was Milford pink granite, quarried by Messrs. Norcross Brothers from their quarries at Milford, Massachusetts:

Test by compression of one 6-inch cube of Milford granite.

[Compressed surfaces faced with plaster of paris to secure even bearings.]

Test number.	Dimensions.			Sectional area.	Ultimate strength.	
	Length.	Compressed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*
2596	5.98	5.83	5.96	34.75	725,700	20,883

Snapping sounds and pieces flew off at 546,000 pounds. Slight explosive sound at 674,500 pounds. Burst into small fragments and sand at the maximum load, accompanied by a loud report. One principal fragment was pyramidal shaped, with sharp apex.

The following analysis of the same stone was made at the School of Mines. Columbia University, New York City, by Prof. C. F. Chandler:

Analysis of Milford pink granite.

	Per cent.
Silica, SiO_2	76.07
Alumina, Al_2O_3	12.67
Ferric oxide, Fe_2O_3	2.00
Oxide of manganese	.03
Lime, CaO	.85
Magnesia, MgO	.10
Potash, K_2O	4.71
Soda, Na_2O	3.37
Total	99.80

MINNESOTA.

Production declined from $155,297 in 1896 to $92,412 in 1897.

While less activity is indicated by these figures, it is also true that in the early part of the present year (1898) prospects are more encouraging, as is indicated by the much more cheerful tone of the replies from producers.

MISSOURI.

The value of the product in 1896 was $107,710; in 1897 the corresponding figure was $97,857. A slight decline is evident, but, as in other States, the early part of 1898 shows an improved outlook.

The granite quarried by the Syenite Granite Company, of Granitevile, Missouri, was tested at Washington University, St. Louis, by Prof. J. B. Johnson, with the following results:

Tests of granite from Graniteville, Missouri.

Number of test.	Size of specimens.	Crushed at—	Crushing strength per square inch.
	Square inches.	*Pounds.*	*Pounds.*
1	3.85	93,100	24,181
2	3.78	95,700	25,317

NEW HAMPSHIRE.

The value of the output in 1896 was $497,966, and in 1897 $641,691.

At Concord and West Concord production was somewhat less active than the year before, but indications there and elsewhere were for improvement in 1898. Concord granite is of thoroughly established reputation, particularly for cut and hammered work.

The granite of Milford, New Hampshire, is highly regarded among granite producers, and its reputation for monumental work seems to be steadily increasing. Indeed, it may also be said that within the past two years this granite has become quite prominent as an admirable stone throughout New England.

NEW JERSEY.

Most of the stone classed here with granite is trap rock and is used for road purposes. Production increased from a valuation of $204,323 in 1896 to $561,782 in 1897. The stone is enormously strong as a rule, and is well adapted for road purposes.

The writer recently tested the trap rock quarried by Messrs. Hatfield & Chamberlain at their quarries at Scotchplains, New Jersey, and found a crushing strength of 35,000 pounds to the square inch.

NEW YORK.

The granite output of this State increased from a valuation of $161,167 in 1896 to $422,216 in 1897. This is a large increase, and is due to the greater activity in the production of trap rock for road purposes.

NORTH CAROLINA.

Production increased from a valuation of $40,017 in 1896 to $59,236 in 1897. All producers report better conditions in 1897. There is much fine granite susceptible of easy quarrying at a number of localities in the State.

PENNSYLVANIA.

The value of the output was $159,317 in 1896 and $349,947 in 1897. Business has been better in general. Some of the increase is accounted for by increased production of trap rock for road making, in which there has been greater activity.

The following is a report by Hermann Fleck, Ph. D., of the University of Pennsylvania, on Birdsboro trap rock, quarried by the John T. Dyer Company, of Norristown, Pennsylvania:

Analysis of Birdsboro trap rock.

	Per cent.
Silica, SiO_2	46.87
Alumina, Al_2O_3	13.36
Ferrous oxide, FeO	2.71
Ferric oxide, Fe_2O_3	9.79
Calcium oxide, CaO	14.70
Magnesium oxide, MgO	4.35
Sodium oxide Na_2O	4.64
Potassium oxide, K_2O	2.01
Titanium oxide, TiO_2	1.98
Total	100.41

The results obtained go hand in hand with those gotten by microscopic examination, which may be summed up as follows: The mineral constituents are plagioclase, pyroxene, and hornblende, with magnetite or magnetic iron to the extent of 4.56 per cent as an accessory constituent. Pyroxene and hornblende predominate.

The rock is, therefore, to be classed as dolorite, valued as one of the best for ballast, roadbed, macadamizing, and paving purposes, excellent examples being found in the so-called French Creek granite and the Palisades of the Hudson, which find a widespread use.

The mineral constituents present impart desirable qualities for a good wearing and durable rock.

Plagioclase and pyroxene add the required hardness on the one hand, while on the other hand hornblende vastly increases the toughness and durability, together making it an excellent material for roadbed and ballast or Belgian block, where these qualities are required.

In addition I may add that such a rock will stand the heaviest traffic without breaking down or splintering. Moreover, it is but slowly attacked by the disintegrating action of frost and thaw, rain, etc., weathering slowly, and then only on the surface, retaining its original hardness throughout the body of the rock.

RHODE ISLAND.

The value of the product in 1896 was $746,277; in 1897 the figure was $629,564. There has thus been some decline, but there is unquestionably a better outlook for 1898, judging from operations so far. Most of the granite quarried in Rhode Island is monumental stock taken from quarries at Westerly and Niantic. Quarrying for building purposes has been taken up more vigorously than heretofore at Westerly, and a large quantity of stone has been quarried for such use.

SOUTH CAROLINA.

The value of the product in 1896 was $55,320; in 1897 the figure was $37,820. Conditions for 1898 are improved.

SOUTH DAKOTA.

Production declined from $199,977 in 1896 to $68,961 in 1897. Some of this product is the Sioux Falls quartzite, a stone of great hardness, strength, and durability. Considerable of the output goes for paving blocks, which have been used to some extent in Chicago.

UTAH.

Very little granite was quarried in Utah, either in 1896 or 1897.

VERMONT.

Production increased from $895,516 in 1896 to $1,074,300 in 1897. Two-thirds of the product came from the Barre region, where, in spite of hard times, production has been active and the stone has been shipped over a large area of the United States.

The following report on the "dark" and "medium" granite quarried by Messrs. Wells, Lamson & Co. at their quarries at Barre, Vermont, was recently made by the writer in the analytical and testing laboratory of Swarthmore College, Swarthmore, Pennsylvania.

REPORT ON DARK AND MEDIUM GRANITE FROM WELLS, LAMSON & CO.'S QUARRIES AT BARRE, VERMONT.

Chemical analysis of dark granite.

	Per cent.
Silica, SiO_2	69.56
Ferric oxide, Fe_2O_3	2.65
Alumina, Al_2O_3	15.38
Manganese	Trace.
Lime, CaO	1.76
Magnesia, MgO	Trace.
Sodium oxide, Na_2O	5.38
Potassium oxide, K_2O	4.31
Loss on ignition, CO_2, and moisture	1.02
Total	100.06

A microscopic examination of this granite was made by Mr. Whitman Cross, of the United States Geological Survey, and his report thereon is as follows:

Messrs. Wells, Lamson & Co.'s dark granite is a fine, even-grained, typical granite containing two micas (biotite, muscovite), sometimes called granite proper. The constituents of importance are quartz, orthoclase, microcline, biotite, and muscovite. The first three occur in wholly irregular grains interlocking in a very complex manner. The micas are in small leaves between and penetrating the other minerals to some extent. Muscovite apparently occurs in two forms, one corresponding to the biotite as seemingly primary and in small flakes in the orthoclase, and clearly a secondary mineral.

Accessory constituents are oligoclase, albite (?), titanite (sphene), and apatite.

There is an almost total absence of magnetite or other iron ore.

Biotite is slightly changed to green, and probably yields chlorite in some samples. The orthoclase gives way to an aggregate of fine muscovite leaves, also varying much in different samples, no doubt.

Both quartz and biotite show that the rock has endured considerable pressure, the former by the "undulatory extinction" it exhibits, and the biotite by the curved and bent lamellæ. The pressure did not extend to a crushing of the grains or any banded structure.

In the feldspars is some calcite filling small cracks. On the basis of this examination I should estimate it at quartz 30 to 35 per cent, orthoclase 30, microcline 20 to 25 per cent. Much of the iron is present in the ferrous or unoxidized condition.

Determinations of specific gravity.

DARK GRANITE.

	Grams.
Weight of granite	8.8061
Weight of water displaced	3.2956
Specific gravity found	2.672
Temperature of water, 22° C.	

MEDIUM GRANITE.

Weight of granite	32.95745
Weight of water displaced	12.37680
Specific gravity found	2.662
Temperature of water, 20° C.	

Determinations of absorption capacity.

DARK GRANITE.

	Grams.
Weight of granite after heating in air at 110° C. for six hours	49.9625
Weight of granite after boiling in water for three hours and wiping dry	50.0230
	.0605
Weight after heating again at 110° C. for six hours	49.9328
Per cent of water absorbed, 0.121.	

MEDIUM GRANITE.

Weight of granite after heating in air at 110° C. for six hours	64.1723
Weight of granite after boiling in water for three hours and wiping dry	64.2549
	.0826
Weight after heating again at 110° C. for six hours	64.1534
Per cent of water absorbed, 0.129.	

Determinations of crushing strength of "dark" and "medium" Barre granite from Messrs. Wells, Lamson & Co., using the standard Tinius Olsen testing machine, of Philadelphia.

DARK GRANITE.

[Crushing strain applied perpendicular to rift.]

No.	Size.	Area	Broke at—	Crushing strength per square inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*
1	2 high × 2 × 2.02......	4.04	71,870	17,790
2	2 high × 2.03 × 2.07 ...	4.20	70,220	16,719

[Crushing strain applied parallel to rift.]

No.	Size.	Area	Broke at—	Crushing strength per square inch.
3	2 high × 2.06 × 2.04 ...	4.20	83,820	19,957

MEDIUM GRANITE.

[Crushing strain applied perpendicular to rift.]

No.	Size.	Area	Broke at—	Crushing strength per square inch.
1	2 high × 2 × 2.02......	4.04	72,140	17,856
2	2 high × 2.02 × 2.04....	4.12	61,670	14,968

[Crushing strain applied parallel to rift.]

No.	Size.	Area	Broke at—	Crushing strength per square inch.
3	2 high × 2 × 2.03	4.06	64,170	15,805

While the foregoing results speak plainly for themselves to the effect that the "dark" and the "medium" granite quarried by Messrs. Wells, Lamson & Co., at their quarries at Barre, Vermont, are unquestionably commendable for the customary uses of granite, it may be well to call attention to certain features of these results which are worthy of special mention. The analysis shows a low percentage of iron, rendering liability to stain a minimum, a high percentage of silica, and the usual percentages of other constituents found in true granites.

The crushing strength of the "dark" granite is high, much above the average for true granite, and somewhat higher on the average than that of the "medium."

An examination of the stone at the quarries by the writer shows it to be unusually free from knots and streaks or irregularities in structure of any kind.

The absorption capacities of both "dark" and "medium," while showing a slight difference in favor of the "dark," are both so low as to amount to virtually nothing when possible disintegration from freezing of absorbed moisture is considered. In this connection it must be remembered that in the absorption tests the stone is so treated as to absorb the maximum quantity of water, i. e., the conditions of the test are far more severe than any natural conditions to which the stone is ever likely to be exposed.

Most of the Barre producers report a very encouraging outlook for 1898.

VIRGINIA.

The value of the granite output declined from $95,040 in 1896 to $88,096 in 1897.

A number of the Virginia quarries produce fine stock, but as yet there has been no recovery from the effects of the financial depression of the last few years.

The following chemical analysis and tests of the granite quarried by the Petersburg Granite Quarrying Company at their quarries at Petersburg, Virginia, were made by Messrs. Hunt and Clapp, at their Pittsburg testing laboratory:

Analysis of granite from Petersburg, Virginia.

	Per cent.
Silica, SiO_2	64.12
Alumina, Al_2O_3	20.91
Oxide of iron, Fe_2O_3	2.96
Lime, CaO	1.98
Magnesia, MgO	.66
Sodium oxide, Na_2O	4.57
Potassium oxide, K_2O	4.82
Total	100.02

Constituent minerals of granite from Petersburg, Virginia.

	Per cent.
Mica	15
Feldspar	60
Quartz	25
Total	100

Test of 2-inch cube of granite from quarries at Petersburg, Virginia.

Original dimensions, 2 inches square.
Original area, 4 square inches.
Ultimate load, 100,400 pounds.
Crushing strength, 25,100 pounds per square inch.

WISCONSIN.

Production in this State has remained practically the same as in 1896, when the output was valued at $126,639.

An analysis of the granite quarried by the Milwaukee Monument Company, at their quarries in Waushara County, was made by Mr. A. S. Mitchell, chemist, of Milwaukee, giving results as follows:

Analysis of granite from Waushara County, Wisconsin.

	Per cent.
Silica, SiO_2	76.62
Alumina, Al_2O_3	13.02
Ferric oxide, Fe_2O_3	1.01
Lime, CaO	.51
Magnesia, MgO	.05
Oxide of sodium, Na_2O	2.24
Oxide of potassium, K_2O	6.38
Total	99.83

NOTES ON GRANITE IN NEW ENGLAND.

During the summer of 1897 the writer had opportunity to visit some, though for lack of time not all, of the leading granite-producing regions of New England. These notes are intended to give some of the results of observations made. In the order of the value of the granite produced, the New England States rank as follows: Massachusetts, Maine, Vermont, New Hampshire, Rhode Island, Connecticut. These States produce annually from 65 to 70 per cent of the total output of the United States. The products of some of these quarry regions have a national reputation and are shipped to all parts of the United States.

The leading position of the New England States in respect to granite production is due to a combination of circumstances and facts, among which may be mentioned the age of this region of the country, the fact that granite is found in great variety and abundance, and finally the fact that many of the quarries are favorably located for cheap transportation of the products by water to the various points of consumption. Such advantages of location on the water are the possession of quarries in Maine, some in Massachusetts, Connecticut, and elsewhere, but they are of less importance now than formerly. At present much of the most valuable monumental granite is, from necessity or choice, shipped from the points of production by rail.

MASSACHUSETTS.

This State has always been the leader in magnitude of output. The principal producing localities are Cape Ann (including Rockport, Pigeon Cove, Lanesville, and Bay View) and Quincy (including West Quincy). These two regions produced in value somewhat more than half the total output of the State, and are about equally productive;

but the uses to which the output is devoted are radically different, in that the Quincy granite is strictly a monumental stone, of national reputation, while Cape Ann granite is primarily a building stone, which can be rapidly quarried and in any desired size of blocks. Other important centers of production in the State are Milford, Monson, Fitchburg, and New Bedford. In addition to these are numerous scattered localities at which valuable stone is produced, but in smaller amounts.

Quincy.—So well is Quincy known as a granite region that it almost seems needless to say anything more. Every stonecutting yard of any importance in all large cities continually has Quincy granite monuments and gravestones displayed for sale or in process of completion to fill orders specifying that stone.

Mineralogically, the stone consists chiefly of quartz, hornblende, and feldspar. There is a high percentage of quartz, and to this is largely due the extreme hardness of the stone. The distinguishing features of Quincy granite, which have given it the high reputation it bears, are its hardness, the durability of the high polish which may be developed, and the contrast between the polished and the hammered surface. This latter feature is more pronounced in the so-called dark Quincy granite than in the light, and for this reason the former commands a higher price.

According to Gillmore the crushing strength of Quincy granite is 17,750 pounds to the square inch; its specific gravity is 2.669. The following analysis was made by Mr. E. R. Angell, chemist of New Hampshire State Board of Health:

Analysis of Quincy granite.

	Per cent.
Silica, SiO_2	75.14
Alumina, Al_2O_3	15.57
Ferrous oxide, FeO	2.49
Lime, CaO	1.85
Potash, K_2O	.54
Soda, Na_2O	4.41
Total	100.00

The qualities of the granite are such as to render it so desirable for monumental work that it is inexpedient to devote the best of it to any other use, and very little determined effort is made by producers to extend its application to building purposes, for which it is also admirably adapted.

Granite for monumental use must be carefully selected, and there is consequently considerable waste of material, which would serve excellently for building, but the producers seem to make but little effort to dispose of stone for this purpose, although not a little finds its way into retaining walls and bridges erected by railway corporations along their lines. Occasionally, also, the granite is used in large and pretentious buildings, but not to the extent to which the qualities of the stone would seem to justify.

Many of the producers at Quincy have been engaged in quarrying for monumental work only for many years, and considerable conservatism as to business policy is the not unnatural result.

Quarrying for monumental stock and for building material are two quite different operations, and if one of these is emphasized at all the other is apt to receive but little, if any, attention. To operate a quarry producing both kinds of stock at the same time, and withal to develop the quarry with due regard to future operations, is a difficult matter, and requires, moreover, a liberal working capital. This is, in many cases, lacking. There is at Quincy a strong temptation to quarry for to-day only. A fine piece of monumental stone is visible in a certain part of the quarry; it can be sold for cash as soon as taken out; it is therefore removed as quickly as possible, and in many cases without such thought for the morrow as will make future operations economical.

Refuse stone is frequently freely and generously given to paving-block cutters, who cut it into paving blocks and sell them on their own account. Knots, streaks, and "mud holes" must be carefully avoided in a conscientious selection of stock for monumental work; but these defects, except the third, would be of but little moment in stone devoted to a wide range of building purposes.

In former years the production of paving blocks was actively carried on, but as many quarrymen put it, the paving-block industry has "gone to the dogs," owing to the competition of other kinds of paving material. While paving blocks are still being made to a slight extent there is very little profit in the business, the maker of the block being able to realize little more than $1 per day for what is very hard manual labor. Paving cutters in the past few years, owing to difficulty in securing other kinds of work, have been obliged to cut blocks for small return or do nothing at all.

The methods of quarrying at Quincy are to blast with lewis holes and then cut into blocks by plug and feather. Sometimes, but not often, channeling is resorted to, but the hardness of the stone is such as to make this very expensive. In channeling, holes are drilled with a steam drill, an inch apart, and then the partitions between the holes are broken down with the channel bar.

Quincy granite is at present used chiefly in the Eastern and Middle States, less being sold in the West than formerly. This is accounted for in two ways; in the first place but few, if any, Quincy salesmen are sent to the West, and Eastern granites that are more easily quarried, and hence cheaper, are largely monopolizing western trade.

Cape Ann.—As already stated, this region includes Rockport and vicinity, Pigeon Cove, Bayview, and Lanesville.

Methods of quarrying and handling stone here offer a strong contrast to the conditions at Quincy, for the reason that monumental work is ignored at Cape Ann, and building stone is the product sought. The stone is decidedly less valuable per cubic foot, and the amounts disposed of and the methods of working must compensate for this. Everything must be done on a large scale, and explosives must be used much more freely than would be permissible in quarries where smaller amounts of more valuable stone for monumental work are sought.

In every way Cape Ann seems to be suited to the production of building stone. In the first place, it is on the coast, and all stone is shipped by water on ships that can come almost to the edge of the quarries. In the second place, the granite is enormously abundant and well adapted to heavy building work, in that it can be taken out in large blocks by expeditious methods of quarrying. In the third place, the construction of an extensive and much-needed breakwater by the United States Government enables quarrymen to dispose of all grout at prices which help them to keep quarry property well cleaned up at less expense than is required at other less favorably located quarries.

The stone is a hornblende-biotite granite, medium to coarse in texture, gray in color, massive, and with both horizontal and vertical joints. It takes a good, durable polish, but, being a light-colored stone, the contrast between hammered and polished surfaces is not so strong as in some of the granites having an established reputation as monumental stones. Very little if any effort is made to push the stone as a monumental material, but the quarrymen seem as a rule to be content with the large possibilities of building, and quarries are equipped for operations on the scale necessary for extensive building contracts and the heaviest foundation work. An important contract recently on hand was the foundation work on the new terminal railway station in Boston, now in course of construction. A few years ago the production of paving blocks constituted an important item in the business of Cape Ann quarrymen, but, as at other localities, this is now suffering from depression and can no longer be regarded as cutting much of a figure in the total output of the quarries. The stone is well adapted for paving, and during the years when paving blocks were in active demand in large cities a product of considerable magnitude was turned out.

The breakwater in course of construction will eventually make a fine harbor at Pigeon Cove, while at present the lack of it is rather a menace to vessels at anchor, or even at the wharves. The dimensions of the completed breakwater will be 50 feet wide at the bottom, 30 feet at the top, 18 feet above high water, and 2¼ miles long. About 800,000 tons of stone have already been put in place. About 6,000,000 tons in all will be required for the completion of the work. The good effects of what has already been done are said to be unmistakably manifest in lessening the violence of the water in the area partially inclosed.

If the work were vigorously pushed it is said that it could be completed in about fifteen years. About $150,000 is annually appropriated for the breakwater work. Stones varying in weight from 50 pounds to 6 tons are used. Dumping scows of special construction are employed, and a whole load is dumped at once by means of ingenious devices adapted to the needs of this particular breakwater.

Care is needed to prevent what is termed the "wandering" of stones in sinking through the water. This is liable to take place if the entire load is not dumped in one mass.

Another use to which considerable stone has been devoted is its employment in concrete in the construction of Government fortifications.

The methods of quarrying are in general similar to those of other regions, but are all carried out on a large scale. Powder is quite freely, but carefully, used. Good railway facilities for transportation to the docks are provided.

A few large concerns do most of the business, which seems to be economically and judiciously conducted.

Some of the Cape Ann granite is iron stained, and on casual inspection might be taken for sap. However, it is not such, but a very tough, durable stone, which is well adapted for use in paving blocks or retaining walls. There is, of course, as at all quarries, plenty of sap, but it is not identical with the iron-stained rock to which reference has just been made. Sap is not only stained from exposure, but shows signs of weakness and disintegration which render it unfit for construction work.

Cape Ann granite is quite free from knots or streaks, is very hard, splits well, occurs in enormous masses, and can be quarried in large blocks. Its special field is heavy work—massive foundations and bridges. The stone is so abundant that blasting may be resorted to freely in cases which at other localities would be treated by slower processes. Blasting may sometimes sacrifice material, but good stone is so abundant that, on the whole, blasting is more economical.

CONNECTICUT.

The most important granite quarries in Connecticut are on or near Long Island Sound.

Groton.—At Groton, just across the river from New London, are a few granite quarries producing only monumental stock. The stone is fine-grained, hard, and well adapted to this use. The valuable stock is in some of the quarries overlain by a large mass of rock, marked by numerous black dikes very much curved and folded and separated from the true granite by a sharp line of division. Under the sheet of granite is another thick mass of bastard rock. Quarrying is done on a small scale only, and is somewhat expensive owing to the large amount of stripping that has to be done. At Center Groton, 5 miles or more from Groton, is another isolated quarry capable of producing fine monumental stock in large quantity if capital were invested in sufficient amount. A long haul by wagon is necessary, and this is quite a drawback. Investment of more capital is imperative before anything considerable can be done at this point.

Waterford.—A large quarry at this point is operated by Messrs. Booth Brothers. The stone is fine-grained biotite granite, of gray color. Operations are quite extensive, both monumental and building stone being produced. The stone is of fine quality, and preparations for even greater activity were being made, as the quality of the stone is such as to amply justify extensive work as soon as production again assumes normal proportions. Work here has been prosecuted actively for the past five years, although in times past quarrying has been done on a smaller scale than at present.

The cutting, carving, and polishing plant is extensive, and at the time of the visit of the writer was being still further enlarged by the erection of a shed 220 feet long, intended to accommodate 100 men in the work of cutting and polishing.

Millstone.—Here is a large quarry, known as Henry Gardiner's quarry. This was originally opened in 1830. Even as far back as one hundred and fifty years ago millstones were quarried for use in the old-fashioned windmills, the ruins of which are in many cases still to be seen near Newport and elsewhere. The quarry is well equipped with modern machinery, and is also provided with a private railroad connecting with the New York, New Haven and Hartford Railroad at Millstone Station. When polished, the color of the stone is rather dark, and this shows a good contrast to the hammered surface, which is light in comparison. The stone is used chiefly for monumental work, although building stone is also quarried. Paving blocks in time past have been turned out in large quantities, but at present but few blocks are made, owing to the reduced demand for such paving material in large cities.

A stone crusher was in operation to furnish crushed stone for the Government fortifications at Dutch Island and elsewhere. Shipping facilities, both by land and water, are exceptionally good.

Stony Creek.—At this place are a few quarries producing a highly feldspathic, coarse-grained, pink stone, well adapted to building purposes. Pink granite is at present quite popular among builders, and the attractive feature of this granite is its color. Contracts for stone for some large buildings, such as the New York Life Insurance building, at the corner of Broadway and Leonard streets, New York City, were on hand during the past year. Preparations for a large increase in output were under way at the time of my visit.

Sachem Head.—At Sachem Head quarrying operations of very different character from those usually adopted are carried out on a large scale, for the single purpose of obtaining stone for breakwaters. A bluff 1,500 feet long has been exposed. From this the stone is removed by the most violent explosives, while in addition any and every way of dislodging stone cheaply is freely applied. Having been loosened out, regardless of size and shape, the stone is loaded on cars which carry it to scows and barges at the wharf a few hundred feet away and it is then transported to the breakwater now in course of construction at Point Judith. The plant for handling and transporting stone is very complete, and altogether represents the investment of nearly $500,000. The firm operating here, Messrs. Hughes Bros. & Bangs, makes a specialty of breakwater and canal work, and, in addition to extensive contracts for breakwaters, are also engaged in supplying limestone at Buffalo for use in the Erie Canal. The workmen are all Italians.

Leete Island.—On this island a highly feldspathic pink gneiss is quarried for heavy construction and bridge work. It was used in the foundation of the Statue of Liberty, in New York Harbor.

This stone has an excellent reputation for the purposes to which it is generally applied. It takes a good polish, and, from the wavy lines that were well shown in a polished slab which was exhibited, would look well in interior decoration in buildings.

Meriden.—At Meriden are quarries of trap rock, which is used only for railroad ballast and highway construction. The stone is fed into crushers and sold for ballast or macadam. Roads around Meriden, where the stone has been used, testify to the excellence of this stone for such use. Not only is the stone of remarkable strength and toughness, but as it slowly pulverizes the dust cements together at every wetting, making a surface of extreme smoothness. The stone seems to be the ideal road material. At one place the stone occurring on the mountain side is in small fragments, which are raked down and transported to the crushers. This operation can hardly be called quarrying. From the solid masses in the quarry the rock is blasted by violent explosives, which are intended to shatter the stone as much as possible, thus reducing the work of the crushers. An improvement in stone crushers consists of the use of manganese steel, which in the form of a pestle rotates eccentrically in a hopper. This form of crusher lasts much longer than ordinary steel-jaw crushers, which have been generally used.

Ansonia.—Near this place are a few small quarries producing gneiss well adapted for street curbing, for which purpose much of the stone is used. The stone splits exceptionally well.

RHODE ISLAND.

This State has been distinguished as standing in first place for the value of monumental work produced. The most important quarries for monumental granite are at Westerly and Niantic. At some of the quarries only monumental stone is produced, but at others building stone also is sold in very large quantities.

Westerly and Niantic.—The monumental stock from these places is distinguished commercially as blue and white, the former being more valuable on account of the better contrast between polished and hammered surfaces. The stone is a biotite granite, of a crushing strength of 17,750 pounds to the square inch. Its value for monumental work is due to its fine grain, uniformity, and the fact that it may be safely carved to a fine edge, which it will hold without danger of chipping. In short, it is exceptionally well adapted to elaborate carving on blocks of great size. Many notable statues and monuments have been made of this stone, and its reputation has been established by years of experience.

Care in selecting stone has to be exercised, as streaks and knots occur. Some of these do not reveal themselves until polishing or carving brings them into view. As the producers are conscientious in letting only good stock leave the yards, there is occasionally financial loss, due to the necessity for condemning a piece of work after considerable labor of an expensive kind has been done.

Some of the quarrymen are opposed to selling stock in the rough, but prefer to dispose of only finished products, as they can thus better protect the high reputation of the stone.

The largest block ever quarried here was 55 by 10 by 5 feet. Facilities for quarrying, cutting, polishing, and carving are of a high order at a number of the Westerly quarries. The latest improvements in all directions are tested promptly, and, if found satisfactory, adopted. At one of the Westerly granite works considerable granite is sawed, with good results as to character of work and economy. Sawing granite is a comparatively new process, and it can not be said to have yet come into anything like general use, but it is favorably regarded by a number who have tried it.

Since the financial depression began a few years ago, the use of Westerly granite for building purposes has increased, and a number of large contracts have been filled or are now on hand. Some of the older quarries are now quite deep, and, although some very fine stone is taken out at considerable depth, the expense of quarrying is somewhat increased. Some of the producers, therefore, have found it necessary to extend their quarries laterally in order to obtain a larger volume of stone sufficient to accommodate building contracts as well as monumental work.

At no place in the United States is finer or more artistic work in carving and sculpture done than at Westerly. In monumental work Westerly granite has marked advantages over many others, but in building work it has no such advantages, and hence must be sold for building at prices which will allow it to compete with granites quarried for building only.

Granite is quarried at Centerdale, Pascoag, Narragansett, Newport, Coventry Center, Greenville, and a few other localities, but the amounts are small as compared with those produced at Westerly and Niantic.

Centerdale.—The stone produced at Centerdale is adapted to street work or rough building. The general tone of color is light, with a greenish tinge. The feldspar is faint pink in color. Quarrying operations are on a small scale.

Greenville.—At this point a hard, durable granite, suitable for building or street work, is produced. The stone contains a biotite here and there, giving a spotted appearance. The chief minerals are quartz and feldspar. The stone is used in Providence and Pawtucket for curbing and foundation work. It is also an excellent stone for engine beds. The stone looks well in rock-faced work. It is easily quarried, but has to be hauled 5 miles to railroad.

Pascoag.—The stone quarried at this place is a biotite gneiss, which splits very well. It is used for bridge work, curbing, and paving in Providence.

VERMONT.

Barre.—Over two-thirds of the granite output of Vermont comes from quarries at or near Barre, and is known as Barre granite. Special interest, therefore, attaches to this region. The stone is distinguished commercially as "light, medium, and dark," these terms applying, of course, to the color. The dark Barre is the most valuable, on account of the stronger contrast between the polished and hammered surfaces, and also on account of superiority in other respects. The light granite occurs in rather regular sheets, while the dark granite presents a very different mode of occurrence, the sheets being more irregular, so that a "dark" granite quarry looks more like a bowlder quarry than a sheet quarry. In quarrying the light granite considerable channeling is done. While such work is expensive, the rock is valuable and uniform enough to justify the extra pains. The dark granite is worked very differently from the light, in that more blasting is done, but without serious damage to the stone, particularly where the Knox system of blasting is used. In the light granite the frequent sticking of the drills gives evidence of considerable pressure in the granite. This is also borne out by microscopical examination, which proves the existence of strong pressure. Barre granite is remarkably free from flaws, such as white-horse and dark-horse knots, and streaks of all kinds. While blemishes are occasionally met, they are so infrequent that it is an easy matter to throw out such material without much loss.

The stone is easily and cheaply quarried as compared with that at some other places producing monumental stock.

The granite is what might be called "granite proper," consisting of quartz, orthoclase, microcline, biotite, and muscovite. The quarries are all on a hill or mountain, and the quarried stone is transported either by rail or by wagon to the town of Barre, a few miles distant. The granite industry at Barre has been built up within the past eighteen years, during which time progress has been steady and satisfactory. The features which have contributed markedly to this success are the favorable situation of the quarries for transportation to the railroad, the ease of quarrying, the uniformity of the granite, and its freedom from knots, streaks, etc. While granite of equally fine quality for monumental work is produced at other places, the quarries at Barre yield a stock which is so uniform that the amount which has to be rejected and thrown on the dump is less. Lower prices for Barre stock are probably, therefore, just as remunerative to the quarryman as the higher prices which have to be charged in other places on account of a greater percentage of waste or the fact that the quarries have reached an inconvenient and expensive depth. The producers at Barre show considerable enterprise in advertising their products and in getting them before the public through the agency of traveling salesmen and in other ways.

Facilities for cutting, carving, polishing, and finishing in every way are abundant and thoroughly up to date, and even in the hard times that have characterized the past few years the Barre producers have more than held their own.

There was considerable talk at Barre in the fall of 1897 relative to the formation of a syndicate which should unite the whole region under one management. This, however, has not resulted in accomplishing anything as yet.

NEW HAMPSHIRE.

The granite industry of New Hampshire is old and well established. The most important localities from the standpoint of value are Concord and West Concord, Milford, Suncook, and Fitzwilliam. Stone is also quarried at a number of other localities.

Concord and West Concord.—The quarries at Concord and West Concord are the most productive. Rattlesnake Hill, near Concord, is the source of most of the stone. The granite is used to a larger extent for building than for monumental purposes. This stone was used in the Library of Congress building at Washington, and has met with general approbation in its use for that purpose. For cut and hammered work in buildings there are few if any granites that surpass Concord stone.

The introduction of more working capital and the provision of better transportation facilities from Rattlesnake Hill to the town are quite evidently needed, and would do about all that is required to make the industry flourish to a degree far beyond what is possible under existing conditions.

The stone, being light in color, has to be carefully selected so as to be free from flaws. This, however, can quite easily be done, as there is a great abundance of entirely satisfactory stone.

The stone is a muscovite-biotite-granite, fine grained, and occurs in sheets. Quarrying is comparatively easy. Very little if any staining results from exposure in buildings.

MARBLE.

The following table shows the value of the output of marble in the United States for the year 1897, by States:

Value of marble product in 1897, by States.

State.	Value.	State.	Value.
California	$48,690	New York	$354,631
Colorado	99,600	Pennsylvania	62,683
Georgia	598,076	Tennessee	441,954
Idaho	5,000	Vermont	2,050,229
Maryland	130,000	Total	3,870,584
Massachusetts	79,721		

An increase of $1,011,448 over the figure for 1896 has been realized. This is due largely to greater activity in Vermont, although a notable increase is also evident for California, while Colorado appears for the first time with an output of $99,600.

The figures for 1897 are the highest ever reached in the history of marble production in the United States.

Since much of the marble quarried is devoted to monumental or cemetery work and interior decoration, and is therefore something ot a luxury, the increase in output for 1897 may be regarded as quite significant of return toward general prosperity.

The following table shows the various uses to which the marble quarried in 1896 and 1897 was put:

Distribution and value of output in 1896 and 1897 among various uses.

	1896.	1897.
Sold by producers in rough state	$583,690	$477,856
Sold for outside building	1,036,163	1,074,646
Ornamental purposes	65,365	9,010
Cemetery work (monuments and tombstones)	813,146	1,547,469
Interior decoration in buildings	329,804	576,983
Other scattering uses	30,968	184,620
Total	2,859,136	3,870,584

The following table shows the purposes for which the marble of the various productive States was sold by the quarrymen in 1896 and 1897:

Value of the marble product, by uses and States, in 1896 and 1897.

State.	Rough.	Building.	Ornamental.	Cemetery.	Interior.	Other.	Total.
1896.							
California	$4,000						$4,000
Georgia	171,644	$258,886		$98,200	$63,650	$25,000	617,380
Idaho	1,500			4,000			5,500
Iowa	23,460	10,080	$6,200				39,740
Maryland		109,000			1,000		110,000
Massachusetts	14,763	56,641		8,000	3,000	1,500	83,904
New York	69,072	365,737		41,682	4,471	3,198	484,160
Pennsylvania	3,022	28,500					31,522
Tennessee	190,103				190,000	1,270	381,373
Vermont	106,126	207,319	59,165	661,264	67,683		1,101,557
Total	583,690	1,036,163	65,365	813,146	329,804	30,968	2,859,136
1897.							
California	8,280	2,625	4,900	3,015	27,310	2,500	48,690
Colorado					82,000	17,600	99,600
Georgia	198,198	145,875		157,803	71,200	25,000	598,076
Idaho				4,500	500		5,000
Maryland		130,000					130,000
Massachusetts	1,026	58,608	306	2,300	16,481	1,000	79,721
New York	11,066	274,626		61,631	5,308	2,000	354,631
Pennsylvania		56,000		6,683			62,683
Tennessee	147,679	4,000		15,625	259,025	15,625	441,954
Vermont	111,607	402,912	3,744	1,295,912	115,159	120,895	2,050,229
Total	477,856	1,074,646	9,010	1,547,469	576,983	184,620	3,870,584

The following table gives the production of marble, by States, for the years 1890 to 1897, both inclusive:

Value of marble, by States, from 1890 to 1897.

State.	1890.	1891.	1892.	1893.
California	$87,030	$100,000	$115,000	$10,000
Georgia	196,250	275,000	280,000	261,666
Idaho				4,500
Maryland	139,816	100,000	105,000	130,000
Massachusetts			100,000	
New York	354,197	390,000	380,000	206,926
Pennsylvania		45,000	50,000	27,000
Tennessee	419,467	400,000	350,000	150,000
Vermont	2,169,560	2,200,000	2,275,000	1,621,000
Scattering	121,850	100,000	50,000	
Total	3,488,170	3,610,000	3,705,000	2,411,092

Value of marble, by States, from 1890 to 1897—Continued.

State.	1894.	1895.	1896.	1897.
California	$13,420	$22,000	$4,000	$48,690
Colorado	....	....	....	99,600
Georgia	724,385	689,229	617,380	598,076
Idaho	3,000	2,250	5,500	5,000
Iowa	....	13,750	39,740	....
Maryland	175,000	145,000	110,000	130,000
Massachusetts	....	2,000	83,904	79,721
New York	501,585	207,828	484,160	354,631
Pennsylvania	50,000	59,787	31,522	62,683
Tennessee	231,796	362,277	381,373	441,954
Vermont	1,500,399	1,321,598	1,101,557	2,050,229
Total	3,199,585	2,825,719	2,859,136	3,870,584

THE MARBLE INDUSTRY IN INDIVIDUAL STATES.

The following is a consideration of the marble industry in the individual productive States:

CALIFORNIA.

A notable increase marks the past year, namely, from $4,000 in 1896 to $48,690 in 1897.

The following data as to the composition and properties of the marble of Colton, San Bernardino County, were obtained by Prof. E. W. Hilgard, of the University of California:

Composition of Colton marble.

	Per cent.
Carbonate of calcium	92.9
Carbonate of magnesium	4.5
Black minerals	2.6
Total	100.0

The black minerals consist of biotite and pyrolusite. The minerals coloring the marble are very refractory to the action of the air and will produce no spotting under ordinary conditions. The stone is therefore a very durable one under any conditions in which marble is likely to be placed, whether in rough ashlar work or with polished face.

Prof. Frank Soule, of the University of California, found the crushing strength to be 9,350 pounds to the square inch.

Of the marble quarried by the Carrara Marble Company, at their quarries in Amador County, Prof. E. W. Hilgard is quoted as follows:

> I find the marble of the Carrara quarry, of Amador County, Cal., most remarkably uniform and free from flaws; partly pure white and partly pleasingly shaded with bluish and black veins. I find it to contain only four-tenths of 1 per cent of minerals other than carbonate of lime. Few marbles are found so pure and charmingly veined. It contains a very small proportion of magnesia, a large percentage of which is a characteristic in all other California marbles. The marble of the Carrara quarry will stand exposure to the weather and scarcely ever become stained, as other marble will.

The following information in regard to marble at Healdsburg, Sonoma County, near San Francisco, quarried by the Healdsburg Marble Company, is submitted by the quarrying company. Mr. George Madeira, mining engineer and geologist, made the scientific observations:

> The marbles crop along the summit of a high ridge or mountain. Barometrical readings show an elevation of 1,640 feet above sea level, and 1,400 feet above the level of a creek flowing at base of the mountain. The croppings vary in width from 200 to 600 feet.
>
> The marbles, carbonates of lime, silicates of magnesia, etc., consist of banded green breccia, brown breccia or Potomic marble, and veined serpentine of every hue and color. The reticulation or veining is of white, green, brown, red, and yellow alternating. The base of the stone is formed of patches or zones of yellow, brown, dove, blue, red, etc., the golden and green veined marbles being very handsome. The deposit, which is composed of tilted, stratified serpentine, stands at an angle of 70 degrees, pitching north, crops on the top of the ridge, and runs south for a distance of 1,500 feet, where it passes under the overlying strata. The dike, ledge, or deposit comes up through the Miocene or bituminous slates, which are seen in situ lower down the slopes of the hill on the south (coast) side.
>
> For a distance of 600 feet along the deposit the marbles alternate. At the south end of this 600 feet the marbles suddenly shoot up above the surface of the terrace on the east side to a height of 65 feet, standing directly at right angles to the trend of the lode. This high wall of Potomic and white marble has prevented the higher ridge backing it from being worn away by the action of the elements, and, in a great measure, covers the deposits southward. The croppings and detached pieces of "float" thickly strewing the hill slope indicate that the deposit continues on and into the lands of the South claim. In the South claim, beside the marbles supposed to underlie the surface croppings, chrome iron ore is found as "float" all over the surface, and at one point a deposit of 75 or 100 tons crops above the surface. Blocks of marble of any desired shape can be obtained from these extensive deposits. There is, in fact, a mountain of marble.
>
> The deposits are situated 11 miles from a railroad station. The main country road is within 1 mile of the deposits, and this length of road will have to be constructed, at a cost of about $700. There is another railroad depot about 7 miles from the place, and in this direction there would be 1½ miles of road to make, costing probably $1,100. Another railroad point can be reached by constructing a road 4½ miles long, at a cost from $3,000 to $5,000. This road would run all downhill; on this line of road, about 2 miles from the deposits, there could be erected workshops, etc., for finishing up the marbles, as there is abundant water power all the year round. There is no machinery yet on the property, and but little has been done in the way of development, though the prospects so far are excellent. The 1 mile of the road could be made in three weeks.
>
> In weight the marbles average about 14 cubic feet to the ton of 2,000 pounds. The green or peacock marbles sell for much higher figure than the serpentine. Capital is needed to develop the property, and the product could be mined and shipped to San Francisco, and thence to Eastern States, South America, Australia, the Orient, etc.

No systematic developments have yet been made, but in several places along the side of the lode the marbles have been cut into, showing the character of the rock. A few inches below the surface croppings the rock is found to be quite solid and free from blemish, particularly the serpentine marbles. Of the green, greater depth will be required to secure large slabs, or columns, than the present superficial development. At one point a tunnel has been driven into the solid serpentine 27 feet along the south side of a band of green onyx marble 6 feet thick, which has not been cut into. In this tunnel the rock became more and more compact with increasing depth below the surface.

Prof. F. W. Crosby is quoted as follows in regard to the verd antique of San Bernardino County:

> The marble belt crops from 10 to 20 feet above the surface, and is from 100 to 300 feet in width. It is composed of a series of ledges from 4 to 6 feet thick. In some instances, on top, these ledges show a thin line of division, but at no great depth they will be found to be practically solid from wall to wall. * * * Blocks can now be obtained containing from 100 to 125 cubic feet without seam or flaw. * * * The marble at the surface of most quarries is worthless, but pieces chipped from the topmost crags of these giant croppings that have been exposed to the elements for countless ages show no traces of decay. On the contrary, the beautiful tints and delicate veins and shading are so perfect as to almost defy any improvement in the character of the stone by deeper workings. It is to be expected, however, as depth is attained, the marble will become a little softer and the colors grow deeper and brighter. * * *
>
> The marble is a verd antique of fine texture, free from faults or imperfections, and susceptible of a very high polish. It embraces all shades of color and tints producible from the commingling of black, white, green, yellow, brown, pale blue, and soft creamy pink. * * *
>
> It is evident that the marble dike extends to a great depth. It seems like a veritable rib of the earth. To all intents and purposes, the quantity of marble is practically inexhaustible.

Capital is at present needed to develop these quarries.

COLORADO.

This State appears in the table for the first time as a marble producer, although attention has been in former reports repeatedly called to the fact of the existence of fine marble in the State. The output for 1897 was valued at $99,600, and it is said by the producers that about the same quantity was also produced in 1896, but no returns to that effect were received in time for publication in the report of 1896.

Mr. Henry Wood, analytical chemist, found the following results in an analysis of the marble from Beulah, Colorado:

Analysis of marble from Beulah, Colorado.

	Per cent.
Carbonate of lime, $CaCO_3$	98.00
Magnesia, MgO	.05
Iron (probably Fe_2O_3)	.04
Silica, SiO_2	.06
Total	98.15

For further data concerning Colorado marble former reports should be consulted.

GEORGIA.

The value of the output in 1896 was $617,380; in 1897 the corresponding figure was $598,076. Since August, 1897, business has been increasing. An exhaustive consideration of the Georgia marble has been given in a former report.

IDAHO.

Five thousand dollars' worth of marble was produced in 1897. It was used for cemetery work and interior decoration.

MARYLAND.

The output increased from $110,000 in 1896 to $130,000 in 1897. The product is largely used for building purposes.

MASSACHUSETTS.

The value of the output differed but slightly from that in 1896.

NEW YORK.

The output fell from $484,160 in 1896 to $354,631 in 1897. In 1896 there was an unusually large product from Tuckahoe, which accounts for the difference in the figures.

The following analysis of marble quarried by the Snowflake Marble Company at their quarries at Pleasantville, Westchester County, New York, was made by Prof. C. F. Chandler, of Columbia University, New York:

Analysis of marble from Pleasantville, New York.

	Per cent.
Calcium carbonate, $CaCO_3$	54.12
Magnesium carbonate, $MgCO_3$	45.04
Ferric oxide, Fe_2O_3	.11
Alumina, Al_2O_3	.07
Silica, SiO_2	.10
Total	99.44

The following analysis and tests of marble quarried by the South Dover Marble Company, of South Dover, Dutchess County, New York, were made by Messrs. Ricketts and Banks, of New York City:

Analysis of marble from South Dover, New York.

	Per cent.
Silica, SiO_2	0.70
Ferric oxide, Fe_2O_3	.25
Alumina, Al_2O_3	.37
Lime, CaO	30.63
Magnesia, MgO	20.25
Oxide of sodium, Na_2O	.12
Oxide of potassium, K_2O	.46
Undetermined and loss	.56
Carbonic acid, CO_2	46.66
Total	100.00

Tests of marble from South Dover, New York.

[Specific gravity, 2.86.]

Porosity: A piece of the marble weighing 143.173 grams and having a volume of 50.05 cubic centimeters absorbs 0.267 grams of water after having been placed therein twenty-four hours.

The following crushing-strength tests were made by Mr. Ira H. Woolsen, M. E., of the engineering department of the School of Mines, Columbia University, New York City:

Crushing-strength tests of marble from South Dover, New York.

[Material, white marble.]

	Test No.		
	1355.	1356.	1357.
How tested	Bed.	Bed.	Bed.
Shape of test piece	Cube.	Cube.	Cube.
Dimensions:			
Length or height, in inches	1.995	1.985	1.986
Diameter or breadth, in inches	2.01	2.02	2.04
Original:			
Thickness, in inches	2.01	2.00	2.00
Area, in square inches	4.04	4.04	4.08
Elastic limit	Slightly.	....	....
First crack	67,800	48,800	77,400
Stress (in pounds):			
Maximum	76,100	70,300	85,200
Compression:			
Maximum per square inch	18,836	17,401	20,882
Average, 19,039 pounds to the square inch.			

PENNSYLVANIA.

The output increased in value from $31,522 in 1896 to $62,683 in 1897.

The product of the Avondale Marble Company is now well introduced to the building public, and has been under scrutiny for several years. The stone is well adapted for building, in point of strength as well as beauty.

The following mineralogical analysis was made at the Michigan Mining School:

Mineralogical analysis of marble from Avondale, Pennsylvania.

	Per cent.
Calcite	59.19
Magnesite	39.17
Quartz, mica, etc	1.64
Total	100.00

The crushing strength was found to be 22,505 pounds to the square inch by the School of Mines of Columbia University, New York City.

It shows very low absorption of moisture.

The Avondale quarries have been equipped with the most modern machinery for quarrying marble, including a powerful derrick capable of handling 100 tons. Another interesting feature is the erection of a mill to be run by electricity. This is now in course of construction.

A peculiarity of this marble deposit is that true granite is quarried from an opening not over 150 feet from the marble opening.

The development of the Avondale quarries is watched with much interest by quarrymen generally on account of the unique features presented and on account of the thoroughly modern methods of conducting the enterprise.

Quarries have recently been opened at Annville, near Swatara, Dauphin County, Pennsylvania, by Mr. J. H. Black. The product is known as Keystone marble. It is to be used for building, interior decoration, and cemetery work.

The following analysis and tests of this marble were made by Prof. G. G. Pond, of the chemical department of State College, Pennsylvania:

Analysis and tests of marble from Annville, Pennsylvania.

	Per cent.
Carbonate of calcium	95.10
Carbonate of magnesium	3.96
Silica	1.07
Oxide of iron	.23
Alumina	.14
Phosphorus	.00
Organic matter	Slight tr.
Total	100.50
Specific gravity	2.67
Crushing test, pounds per square inch	12,210

TENNESSEE.

The value of the output in 1896 was $381,373; in 1897, $441,954; so that an increase is evident. Producers report encouraging prospects for 1898. The output goes largely for purposes of interior decoration, although considerable that is sold by the quarrymen as rough is used in buildings. The so-called "Knox pink" is well suited for outside building.

A full description of the Tennessee marble has already been given in the reports for 1894, 1895, and 1896.

UTAH.

The marble quarried by the Hobble Creek Marble Company was described in the report for 1896. Operations preliminary to quarrying have been carried on during the past year, and an output may be looked for in the near future.

VERMONT.

The output of Vermont underwent a notable increase in 1897, namely, from $1,101,557 in 1896 to $2,050,229 in 1897. More than half of the product of the United States came from Vermont. Most of it was used for cemetery purposes, although some of the quarries now produce building stone on quite a large scale, which appears to be increasing.

Full descriptions of the Vermont quarries have been given in former reports, together with analyses and tests of the marble in some cases.

WEST VIRGINIA.

Although no output from this State has yet been secured, operations looking to that end have been gotten under way by the Pocahontas

Marble Company, of Academy, Pocahontas County, where marble of apparently very desirable properties has been found. It has been examined by experts. The following report by Mr. George C. Underhill shows the nature of the material and its mode of occurrence:

A careful study of the outcroppings indicate, first, that there are several miles of fossiliferous marble strata, perhaps 5 or 6, exposed to plain view much of the distance and nowhere covered by more than a few feet of débris. The vein is at least 40 feet thick and lies nearly horizontal at all points, coursing through and through the low range of hills wherein it is located. There is no possible way to determine the full depth of the stratum except by core drill or uncovering the exposure to a greater depth than has been attempted, or by actual excavation; nor does it matter much whether it be proved to be of greater depth than is shown by outcroppings, for there is more marble already in sight than has ever been used during all the ages, and this statement is in no sense extravagant or overdrawn. An excavation 2,000 feet square and 40 feet deep would produce 80,000,000 cubic feet of merchantable marble--assuming that one-half the excavations be débris—and I seriously doubt whether that enormous gross total has yet been produced, for while the world's production now aggregates perhaps 4,000,000 cubic feet annually, it is only of late that even 1,000,000 was used, and it is probable that 100,000 feet would cover the production of fifty years ago, and proportionately less as we go back. Thus it will be seen that with an area of several miles square available it is not very important to know accurately whether the depth be 40 or 140 feet, especially as a 40-foot stratum can be economically worked.

In quality this marble may be divided into two general grades, one ranging from the richest red to the deepest maroon color, the other dove colored, richly marked with white mottling and dark veins. Perhaps the most important query is as to the condition of this vast mass, for many deposits that are otherwise desirable are so unsound and broken by eruption and upheaving forces as to be rendered worthless.

A word as to the method of its presentation above the adjacent country side will make plain that no great strain could have obtained. The contour of the immediate country surrounding Marble Mountain, taken in connection with the position of all the exposed rocks, makes it sure that the hills in question were forced up from their original level, the level where deposition took place, without tilting or contortion, just as though some force should operate directly under a given piece of level meadow land so as to lift it hundreds or thousands of feet above its natural surroundings, thus making an elevated table-land or mesa, the top being undisturbed and level as before.

I have never seen like conditions except at Dorset, Vermont, where a large bed of low-grade marble and noncrystallized limestone was forced up in a like manner, and where more than half a century's work on an extensive scale shows a practically sound and unbroken mass of marble except in a few spots where it is locally injured, as in case of the "blue ledge" and its immediate vicinity.

The red and maroon marble referred to are counterparts almost of marble found in Hawkins County, Tennessee, and at Swanton, Vermont, both valuable and much sought after. Many years ago the balusters and columns inside the Capitol building at Washington were produced, at great expense, near Rogersville, in the former State, and are standing advertisements for this beautiful material.

The dove-gray varieties have no known counterpart, in this country at least, except in Colorado, where there is a somewhat similar vein. This marble is at once chaste and rich, and would find a ready market wherever beauty is appreciated. Commercially the future of Marble Mountain is largely dependent on a railway outlet, but as a valuable marble field is a great freight producer; and in view of the recent discoveries of coal near by it is not possible that the building of a railway will be long delayed. Moreover, it is almost a wonder that a rich farming district like that bordering the Greenbrier River for the 40 miles or more north from the Chesapeake and Ohio Railroad at Ronceverte should have been so long overlooked by railroad men.

I may add that I was shown one of the finest pieces of black marble that I have ever seen and a fine sample of agate onyx, both of which would aid in making a railroad pay through this valley.

Finally, let me say that under favorable conditions large returns are made from the production of marble, and I feel confident that when it is fully understood that there are large quantities of freight some railway company to the north or south will reach out for it, and the rest will naturally follow.

SLATE.

CONDITION OF TRADE.

The slate industry has been in a comparatively flourishing condition, judging from the increase in value of output from $2,746,205 in 1896 to $3,524,614 in 1897.

This increase is seen, from the following table, to be due to unusual activity in the production of roofing slate, the number of squares of which has, for the first time in the history of slate quarrying in the United States, reached over 1,000,000 squares. The two most productive States, Pennsylvania and Vermont, have, of course, contributed most to this increase, which is due to the export trade and not to increased domestic consumption. Exportations have not been confined to these States alone, but have characterized the trade of others as well.

Tests of slate produced in this country have been made abroad, and the verdict in some cases, if not, perhaps, in all, has been gratifying to American producers.

The average price per square at the quarry of all slate produced has reached the lowest point, namely, $3.09 per square. This, however, is only 2 cents below the average for 1894. It is not unlikely that there will be a slight rise next year. When the demand for slate in this country returns to the conditions of 1891 or 1892 the industry ought to be in a flourishing condition, if the foreign trade is still retained, and there is no reason whatever for believing that such will not be the case.

The export trade began something more than a year ago, and the causes which led to it were fully considered in the report for 1896.

The strike among the workmen of the large slate quarries in Wales has at last, after months of rather bitter feeling, been settled to the satisfaction of employers and employees. This labor difficulty was one of the causes which led to the exportation of American slate, which was needed abroad to supply what had previously been largely forthcoming from the Welsh quarries. Of course the question naturally arises as to whether United States producers can hold the foreign trade they have gained now that the Welsh quarries are again productive.

It is generally believed among American slate producers that this trade can be retained, as the American slate is, on the whole, looked upon with favor abroad and much enterprise has been shown in efforts to popularize our product.

The terms of settlement of the Welsh strike are, according to the American Slate Trade Journal, as follows:

> 1. (*a*) The grievances of any employee, crew, or class shall be submitted by him or them in the first instance to the local manager. If dissatisfied with the decision of the local manager, then the said grievances shall be submitted to the chief manager, either personally or by deputation, appointed in such manner as the workmen may deem advisable, but to consist of not more than five employees selected from the same class as the person or persons aggrieved, who must be included in the deputation.
>
> (*b*) Grievances in which the employees generally are interested, or which they may adopt on behalf of an employee, crew, or class who have submitted their grievances under the preceding clause and are dissatisfied, can again be submitted to the chief manager by a deputation consisting of not more than six employees, appointed in such manner as the workmen may deem advisable.
>
> (*c*) Finally, in a similar manner in all cases of importance an appeal may be made to Lord Penrhyn, either by the individual or by a deputation, against the decision of the chief manager. The grounds of such appeal shall in all cases be first submitted to his lordship in writing.
>
> 2. Suitable monthly bargains will be given without delay as soon as the management finds it practicable.
>
> 3. The letting of the contracts to be left in the hands of the management, who engage all persons employed thereon and see that each employee receives his just ratio of wage.
>
> 4. Previous to the cessation of work the average wage paid to the quarrymen was 5s. 6d. per day, other piecework classes being in proportion (viz, badrockmen 4s. 7d. and laborers 3s. 7d.). When work is resumed this same basis will be continued so long as trade permits.
>
> 5. All the employees who desire work in the Penrhyn quarry will be readmitted in a body as far as it is practicable and the remainder as soon as work can be arranged for them, reasonable time being allowed to those who may now be employed at a distance.

The best evidence that foreign exportation of slate may be regarded as a permanently established practice is that the American Slate Mart and Wharf Company, Limited, of London, England, capital £100,000 ($500,000), was incorporated on September 13, 1897. The object of this company is "to establish, foster, and develop the American slate trade in Great Britain and on the continent of Europe, in all its branches, by the importation of slates from the United States," etc. Mr. William S. Iles, of London, is the head of the new concern, and with him are associated a number of well-known English capitalists. Mr. Samuel Keat, of Pen Argyl, Pennsylvania, is a stockholder and also the sole representative of the company in this country.

A notable improvement in slate quarrying has asserted itself in the comparatively recent adoption of the channeling machine in removing large masses of slate from the quarry. This machine replaces explosives. Blasting, no matter how carefully done, shatters the rock to such an extent that a great deal of otherwise good material is turned into rubbish, resulting in the course of a year in the loss of thousands of dollars. The channeler cuts the rock out so nicely that every part can be used for slate, and the quarry is always clear of rubbish.

PRODUCTION.

The following table shows the output of roofing and milled slate in 1897:

Value of slate product in 1897, by States.

State.	Roofing slate.		Other purposes, value.	Total value.
	Squares.	Value.		
California	1,000	$7,000		$7,000
Maine	38,367	161,262	$39,855	201,117
Maryland	11,592	53,049	890	53,939
Minnesota	400	1,000	500	1,500
New Jersey	250	775		775
New York	9,197	52,799	1,000	53,799
Pennsylvania	657,692	2,034,958	330,341	2,365,299
Vermont	244,575	656,114	39,701	695,815
Virginia	38,375	130,495	14,875	145,370
Total	1,001,448	3,097,452	427,162	3,524,614

The following table shows the average value of roofing slate per square since 1890:

Average annual price per square of roofing slate for the entire country.

1890	$3.34	1894	$3.11
1891	3.49	1895	3.23
1892	3.56	1896	3.36
1893	3.55	1897	3.09

The following table shows the value of the production of slate, by States, during the years 1890 to 1897, inclusive:

Value of slate, by States, from 1890 to 1897.

State.	1890.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	3,104	$18,089	....	$18,089
Georgia	3,050	14,850	$480	15,330
Maine	41,000	201,500	18,000	219,500
Maryland	23,099	105,745	4,263	110,008
New Jersey	2,700	9,675	1,250	10,925
New York	16,767	81,726	44,877	126,603
Pennsylvania	476,038	1,641,003	370,723	2,011,726
Vermont	236,350	596,997	245,016	842,013
Virginia	30,457	113,079	....	113,079
Other States *a*	3,060	15,240	....	15,240
Total	835,625	2,797,904	684,609	3,482,513

State.	1891.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Arkansas	120	$480	....	$480
California	4,000	24,000	....	24,000
Georgia	3,000	13,500	....	13,500
Maine	50,000	250,000	....	250,000
Maryland	25,166	123,425	$2,000	125,425
New Jersey	2,500	10,000	....	10,000
New York	17,000	136,000	40,000	176,000
Pennsylvania	507,824	1,741,836	401,069	2,142,905
Vermont	247,643	698,350	257,267	955,617
Virginia	36,059	127,819	....	127,819
Total	893,312	3,125,410	700,336	3,825,746

a Includes Arkansas, Michigan, and Utah.

Value of slate, by States, from 1890 to 1897—Continued.

State.	1892.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	3,500	$21,000		$21,000
Georgia	2,500	10,625		10,625
Maine	50,000	250,000		250,000
Maryland	24,000	114,000	$2,500	116,500
New Jersey	3,000	12,000		12,000
New York	20,000	160,000	50,000	210,000
Pennsylvania	550,000	1,925,000	408,000	2,333,000
Vermont	260,000	754,000	260,000	1,014,000
Virginia	40,000	150,000		150,000
Total	953,000	3,396,625	720,500	4,117,125

State.	1893.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Georgia	2,500	$11,250		$11,250
Maine	18,184	124,200	$15,000	139,200
Maryland	7,422	37,884		37,884
New Jersey	900	3,653		3,653
New York	69,640	204,776	206	204,982
Pennsylvania	364,051	1,314,451	157,824	1,472,275
Utah	75	450	400	850
Vermont	132,061	407,538	128,194	535,732
Virginia	27,106	104,847	12,500	117,347
Total	621,939	2,209,049	314,124	2,523,173

Value of slate, by States, from 1890 to 1897—Continued.

State.	1894.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	900	$5,850	....	$5,850
Georgia	5,000	22,500	....	22,500
Maine	24,690	123,937	$22,901	146,838
Maryland	39,460	150,568	2,500	153,068
New Jersey	375	1,050	....	1,050
New York	7,955	42,092	2,450	44,542
Pennsylvania	411,550	1,380,430	239,728	1,620,158
Vermont	214,337	455,860	202,307	658,167
Virginia	33,955	118,851	19,300	138,151
Total	738,222	2,301,138	489,186	2,790,324

State.	1895.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	1,500	$10,500	....	$10,500
Georgia	2,500	10,675	....	10,675
Maine	23,774	118,791	$21,363	140,154
Maryland	13,188	59,157	1,200	60,357
New Jersey	200	700	....	700
New York	13,624	90,150	1,725	91,875
Pennsylvania	426,687	1,437,697	210,054	1,647,751
Vermont	221,359	531,482	93,849	625,331
Virginia	27,095	92,357	19,000	111,357
Total	729,927	2,351,509	347,191	2,698,700

Value of slate, by States, from 1890 to 1897—Continued.

State.	1896.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Georgia	4,597	$20,388	....	$20,388
Maine	23,078	99,831	$24,255	124,086
Maryland	15,557	70,194	1,948	72,142
Massachusetts	....	....	1,200	1,200
New Jersey	200	700	....	700
New York	16,002	78,612	3,880	82,492
Pennsylvania	431,324	1,391,539	334,779	1,726,318
Tennessee	160	640	780	1,420
Vermont	155,523	509,681	99,915	609,596
Virginia	26,863	92,163	15,700	107,863
Total	673,304	2,263,748	482,457	2,746,205

State.	1897.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	1,000	$7,000	....	$7,000
Maine	38,367	161,262	$39,855	201,117
Maryland	11,592	53,049	890	53,939
Minnesota	400	1,000	500	1,500
New Jersey	250	775	....	775
New York	9,197	52,799	1,000	53,799
Pennsylvania	657,692	2,034,958	330,341	2,365,299
Vermont	244,575	656,114	39,701	695,815
Virginia	38,375	130,495	14,875	145,370
Total	1,001,448	3,097,452	427,162	3,524,614

THE SLATE INDUSTRY IN INDIVIDUAL STATES.

CALIFORNIA.

Slate was produced in Eldorado County to the amount of $7,000. It has an excellent color, dark blue, and is said to be durable; in fact, there seems to be no question as to the quality of the material for roofing purposes, to which use only has the slate yet been applied.

MAINE.

In Maine production increased from a valuation of $124,086 in 1896 to $201,117 in 1897. Some of the quarries were required to increase working force very materially to fill orders.

The following table gives the results of an analysis of roofing slate quarried by the Monson Slate Company at their quarries at Monson, Maine. The analysis was made by Mr. L. M. Norton, of the Massachusetts Institute of Technology, at Boston.

Analysis of Monson (Maine) slate.

	Per cent.
Loss on ignition, including organic matter	3.88
Silica, SiO_2	56.42
Alumina, Al_2O_3	24.14
Ferrous oxide, FeO	4.46
Lime, CaO	.52
Magnesia, MgO	2.28
Oxide of potassium, K_2O	5.53
Oxide of sodium, Na_2O	3.15
Total	100.38

The following data relative to slate quarried by the East Brownville Slate Company at their quarries at Brownville, Maine, were obtained by Prof. W. O. Crosby, of the Massachusetts Institute of Technology, at Boston:

Two 1-inch cubes were crushed on bed; that is, the pressure was applied in a direction perpendicular to the cleavage. The first cube crushed under a load of 29,420 pounds. while the second yielded at 29,120 pounds. In other words, the average crushing strength of this slate, perpendicular to the cleavage, is 29,270 pounds to the square inch. It is thus much stronger than ordinary building stones, which usually range from 5,000 to 20,000 pounds; in fact, the strength is equaled by very few stones and surpassed by almost none. One cube was crushed on edge; that is, the pressure was applied parallel with the cleavage. It yielded at 16,750 pounds, a higher result than is afforded by most kinds of slate on bed. Two slabs were submitted to transverse or breaking strains; they were of uniform size, 6 inches wide, 1 inch thick, and 11 inches long between the supports. They were laid horizontally upon the supports and the load applied at the middle, bearing upon the entire width of the slab. The first slab, which had been purposely selected because it was visibly imperfect in structure, broke under a load of 2,540 pounds, while the second slab, which clearly shows the normal quality of the slate, required 3,550 pounds to break it.

MARYLAND.

In 1896 the total value of the output was $72,142; in 1897, $53,939; so that there was a slight decline. The outlook for 1898 is said to be improved.

In the report for 1896 results of tests of Maryland Peach Bottom slate were given in detail.

MASSACHUSETTS.

A small quantity of slate was quarried during the year, but apparently not used for the purposes to which slate is usually applied.

MINNESOTA.

A little slate quarrying was done in 1897, but the industry in this State has not yet become permanently established, although there seems to be no reason why it should not.

NEW JERSEY.

A little work was done in New Jersey at Lafayette, where there are a few quarries belonging to the continuation of the Pennsylvania slate belt.

NEW YORK.

The slate of this State is almost entirely red slate, produced in the quarries of Washington County, not far from the Vermont State line. Production declined slightly in 1897.

PENNSYLVANIA.

The output of slate in Pennsylvania in 1896 was valued at $1,726,318; in 1897, at $2,365,299—a very remarkable increase. This is largely due to a continuation of the export trade, which commenced in 1896. Domestic trade was not largely increased over 1896.

The following analysis of slate quarried by the East Bangor Consolidated Slate Company, of East Bangor, Pennsylvania, was made by Mr. Henry Leffman, of Philadelphia:

Analysis of slate from Bangor, Pennsylvania.

	Per cent.
Silica, SiO_2	68.620
Iron oxide	4.200
Alumina, Al_2O_3	12.680
Calcium Carbonate, $CaCO_3$	2.337
Magnesium	3.759
Alkalies	3.730
Moisture and combustible matter	4.470
Total	99.796
Summary:	
Silicates	89.160
Carbonates	6.096
Moisture and cumbustible matter	4.470

The following article is an abstract of a paper by Professor Mansfield Merriam, of Lehigh University, originally published in Vol. XXVII of the Transactions of the American Society of Civil Engineers:

THE STRENGTH AND WEATHERING QUALITIES OF OLD BANGOR ROOFING SLATES.

The roofing slates here described and investigated are those from the quarries of the Old Bangor Slate Company, situated at Bangor, Pennsylvania. The Old Bangor quarry is about 3 miles from the Blue Mountain, and thus at the bottom of the upper or softer slate beds. This quarry is very much the largest in the Bangor region, a great part of its product being manufactured into roofing slates, which, by general reputation, stand high in quality.

The manner of working this quarry is in benches whose surfaces are parallel with the plane of cleavage. As the benches are worked downward, the top is constantly being stripped off in order to allow new ones to be started, and thus the horizontal extent of the quarry is continually increased, its maximum depth remaining at about 125 feet below the original surface of the ground. This method of working in benches is peculiar to this particular quarry, and can be pursued only when the uncovered area is very large. There are five of these benches, each being about 15 feet in height and from 30 to 40 feet in width.

This is the oldest quarry in the Bangor region, having been opened in 1866, and the horizontal uncovered area is now about 500 by 1,000 feet.

Roofing slates.—In the manufacture of roofing slates everything is done by hand except dressing the edges. The blocks delivered at the shanties are first split into thicknesses of about 2 inches. These are piled up in a shanty beside a workman called a splitter, who, with a wooden mallet and a long, thin chisel, divides each into halves, and continues the process until they are reduced to the required thickness of about three-sixteenths of an inch. He then cuts out pieces in approximate sizes, and these are taken by an assistant and squared off into regular shape and size on a dressing machine. The rock requires to be kept damp from the time it is first exposed until it is split into the final sizes, otherwise the cleavage becomes difficult.

Roofing slates are made in numerous sizes, from 14 by 24 inches down to 6 by 12 inches, the longer dimension being that which is placed parallel with the rafters of the roof. In all roofing which is properly done, a triple lap of 3 inches is allowed; thus, for a 24-inch slate 10½ inches are exposed, 10½ inches are covered by the slate above it, and 3 inches are covered by two slates above it. The amount of slate required to cover a space 10 by 10 feet in this manner is called a square, which is the unit by which they are sold. For slates 12 by 24 inches it takes 114 to make a square; for those 8 by 16 inches, 277 makes a square, and so on.

The normal product of roofing slates is called No. 1 stock, and this is entirely free from ribbons. In addition to the first quality there is a small proportion of the product manufactured into No. 1 Ribbon and No. 2 Ribbon, the former containing ribbons near one end only, so that when laid on the roof the exposed parts are free from them. The color of the slate produced in the quarries of the Old Bangor Slate Company is a permanent dark blue. The color of the ribbons, however, is nearly black. This is due to the sulphide of iron which they contain..

The investigations of the properties of slate which are found on record are few, and these are almost entirely by chemical analysis. Silica and alumina are supposed to give strength and toughness, the carbonates of lime and magnesia are liable to be acted upon and washed out by the rain, and the compounds of iron and sulphur are known to promote disintegration under the action of smoke and acid fumes. Something as to quality can therefore be judged by the comparison of chemical analyses, but the information thus obtained is so slight as to have little weight with an engineer, particularly when he considers that the mineralogists inform us that the rocks of the same identical chemical composition may have quite different properties on account of different lithological structure. A chemical test of iron or steel affords but little information to the engineer concerning its physical properties, and he demands that quantitative results concerning its toughness and strength must be known. So it should be with stones and slates.

Method of investigation.—It was purposed in investigating these roofing slates to experiment as closely as possible upon those properties which are called into service in resisting the stresses to which they are subject, and upon those qualities which either assist or resist the disintegrating action of the atmosphere and weather. The strength and toughness of slate are important elements in preventing breakage in transportation and handling, as well as in resisting the effect of hail or of stones maliciously thrown upon the roof. They are also brought effectively into play by the powerful stresses produced by the freezing of water around and under the edges. Porosity, on the other hand, is not a desirable property, for the more water the slate absorbs the greater the disintegrating action when it freezes and thaws. Density is a quality of value, for, in accordance with a fundamental principle of the science of the resistance of materials, the greater the specific gravity of one of several similar substances, the greater is its strength. Hardness may or may not be a desirable quality according as it is related to density or to brittleness. Lastly, corrodibility, or the capacity of being disintegrated by the chemical action of smoke and of fumes from manufactories, is certainly not desired in roofing slates.

A scientific investigation was undertaken to determine these qualities in the Old Bangor slates. In order to do this, such tests were selected as seemed likely to be both precise and simple, and of such a character that quantitative results concerning each of the above properties could be determined. These results will be given below for a number of specimens, and they will be discussed and compared with the view of ascertaining the relation between the different properties. Lastly, by the help of chemical analyses, the relation of the physical qualities to the presence or absence of certain elements is to be studied.

The pieces tested were 12 inches wide by 24 inches long, and varied in thickness from three-sixteenths to one-fourth of an inch. They were all free from ribbons and were presumably of the best product of the Old Bangor quarries. There were twelve specimens, marked 1, 2, 3, 4, etc. These numbers were kept upon the specimens and their fragments throughout the different tests, thus enabling the different properties to be compared for each individual specimen. The general appearance of the slates was very similar.

Strength.—The transverse or flexural strength of the slates was selected for experiment because of the ease and accuracy with which the tests can be made, and also because such stresses are brought upon it in actual use rather than those of pure tension or compression. The pieces were supported in a horizontal position upon wooden knife edges 22 inches apart, and then loads were placed upon another knife edge halfway between the supports. The load was applied by means of sand running out of an orifice in a box at the uniform rate of 70 pounds per minute, and by the help of an electric attachment the flow of sand was stopped at the instant of rupture. The slates were always placed upon the supports so that the beveled edges were on the lower side. As the load was increased the deflection of the slate could be observed upon a scale and the ultimate deflection was recorded.

The strength of a beam or plate broken in this manner is indicated by the modulus of rupture, which is the computed horizontal rupturing stress on the upper and lower fibers, and is intermediate in value between the ultimate tensile and compressive strength. Let W be the load in pounds which causes rupture when applied at the middle, let l be the distance between the supports in inches, b the breadth and d the thickness of the plate in inches. These being carefully found by observation, the formula

$$S = \frac{3Wl}{2bd^2}$$

furnishes the means of computing the modulus of rupture S, whose value is then in pounds per square inch.

In the following table are given the values of the modulus of rupture for each of the twelve specimens. In four cases this value is the average of two tests, the second one being made upon pieces 10 inches long which were cut from the larger broken specimens. The figures for these duplicate tests will be interesting as showing the slight range in the results, and thus establishing the accuracy and value of this method of investigation. They give the following values for the modulus of rupture in pounds per square inch, and the average of these is stated in the table, while for the other specimens tests were made upon the larger sizes only:

Average modulus of rupture, in pounds per square inch, of Old Bangor roofing slate.

Mark of specimen.	B3	B7	B9	B11
S for large slate	9,750	8,420	10,195	8,100
S for small slate	9,720	8,450	10,235	8,140

The mean value of the modulus of rupture of all the specimens is seen to be 9,810 pounds per square inch.

The following table shows tests of Old Bangor slates:

Tests of Old Bangor slates.

	Strength.	Toughness.	Density.	Softness.	Porosity.	Corrodibility.
Mark of the specimens.	Modulus of rupture per square inch.	Ultimate deflection on supports 22 inches apart.	Specific gravity.	Amount abraded by 50 turns of a small grindstone.	Water absorbed in 24 hours.	Weight lost in 63 hours in acid solution.
	Pounds.	*Inch.*		*Grains.*	*Per cent.*	*Per cent.*
1........	11,550	0.32	2.816	151	0.131	0.410
2........	11,540	.38	2.807	140	.170	....
3........	9,740	.31	2.795	76	.099	.439
4........	8,650	.31	2.784	119	.127	.481
5........	7,280	.25	2.779	86	.204	....
6........	9,220	.31	2.759	130	.174	.374
7........	8,440	.27	2.776	119	.167	....
8........	11,570	.40	2.769	130	.123	.551
9........	10,215	.32	2.782	173	.123	.464
10........	10,900	.37	2.767	86	.169	....
11........	8,120	.23	2.769	140	.099	.404
12........	10,490	.32	2.754	184	.152	....
Means..	9,810	.312	2.780	128	.145	.446

Toughness.—The ultimate deflections of the pieces broken under transverse stress furnish an indication of their toughness, in the same manner that the ultimate elongation of a metallic specimen under tensile strain is an index of toughness and extensibility. The greater the ultimate deflection of a bar, the less is its brittleness, and the greater its toughness, other things being equal. All the specimens of slate were so elastic that the deflection of the middle part, where the load was applied, could easily be noted on a scale by the eye, with an error rarely exceeding one thirty-second of an inch. The test can, therefore, be readily made with the simplest apparatus. The results for the individual specimens are seen in the table, all of which were found from the pieces laid upon supports 22 inches apart. The mean values of the ultimate deflection are 0.312 inch.

The toughness of the slate can also be inferred from the manner of rupture of the specimens. It was observed in general that all the specimens ruptured in different planes on the upper and lower surfaces, so that, in fact, it often split or sheared into two thinner sheets, which were then pulled apart from each other. The structure of the Old Bangor slate, therefore, is laminated and very fibrous, and hence tough and strong.

Specific gravity.—The density was next determined for each specimen by weighing it first in air and then in water, from which data the specific gravity was computed. The results given in the table show the mean density to be 2.780.

Softness or capacity for abrasion.—The hardness of the slates was next tested by subjecting them to abrasion upon a grindstone, whose thickness was 1½ inches and diameter 7 inches. A piece of slate about 4 by 4 inches was accurately weighed, and then held against the grindstone by a lever, which exerted a constant pressure of 10 pounds upon it while the grindstone was turned fifty times. The piece was then weighed again, and the difference of the two weights gives the amount ground off. The results thus obtained indicate the hardness, or rather the softness, for the greater the abrasion the softer is the material. The table which gives these results for each specimen shows the mean values to be 128 grains. For a roofing material hardness is not necessarily a valuable quality, and it will appear later in this discussion that the softer slate has the higher strength and weathering qualities.

Porosity.—The well-known test for porosity is to determine the percentage of water absorbed by the specimens under similar conditions. In the absence of standard rules regarding the shape and size of the specimen, its degree of dryness, or time of immersion, the following procedure was adopted: A piece of slate from each specimen was cut to a size about 3 by 4 inches, the edges being left rough and irregular. These were dried for twenty-four hours in an oven at a temperature of 135° F. After cooling to the normal temperature of the room, they were weighed on delicate scales and then immersed in water for twenty-four hours, when they were taken out and weighed again. The difference of these weights, divided by the first weight, gives the percentage of water absorbed by a specimen. The table exhibits the results thus obtained, and it is seen that the mean percentage of the samples is 0.145.

Corrosion by acids.—In order to imitate the action of smoke and of sulphurous fumes of manufactories, the following test was used: A solution of hydrochloric and sulphuric acids was prepared, consisting by weight of 98 parts of water, 1 part of hydrochloric and 1 part of sulphuric acid. In this pieces of slate about 3 by 4 inches in size were immersed for certain periods of time, having first been carefully weighed. After being taken out of the solution they were dried for two hours in the normal air of the laboratory and were again weighed. Thus the loss of weight due to the corrosive action of the acids was ascertained. The results were then transformed into percentages of the original weight, which give an absolute measure of the corrosion. Two specimens of slate were kept for twenty-four hours in the solution, and gave the following percentages of loss of weight:

Corrosion of Old Bangor slate in acid.

	Per cent.
B5	0.297
B7	0.235
Mean	0.266

Two specimens of slate were kept for eighty-seven hours in the acid solution, and there were found the following percentages of loss of weight:

Corrosion of Old Bangor slate in acid.

	Per cent.
B2	0.633
B12	0.696
Mean	0.665

Most of the specimens, however, remained in the acid for a period of sixty-three hours, and from these the percentages of loss of weight were obtained which are given in the table. After the tests the surfaces of the pieces showed but slight traces of acid action, notwithstanding the loss of weight.

These results plainly indicate that the corrosion or disintegration rapidly increased with the time. The sum of these means for twenty-four hours, sixty-three hours, and eighty-seven hours is 1.377 per cent for the specimens, which may, perhaps, be taken as the final value for comparison.

Discussion of the tests.—The above physical tests were mostly made under the writer's direction by Mr. J. P. Brooks, instructor in civil engineering in Lehigh University. Great care was taken to so conduct them that the numerical results would be strictly comparable.

The recapitulation of the mean results of these tests will be useful at the outset of the discussion. These mean values have, according to the principles of the method of least squares, about 12 times the weight of a single determination, and should hence be expected to furnish a tolerably reliable indication concerning the properties under investigation. They are given in the table below, and it is at once seen that the different qualities are connected by definite relations, the strongest slate being the toughest and softest, as also the least porous and corrodible.

Mean results of physical tests.

Property.	Measured by—	Slates.
Strength..........	Modulus of rupture, in pounds per square inch.	9,810
Toughness........	Ultimate deflection, in inches, on supports 22 inches apart.	0.313
Density...........	Specific gravity	2.780
Softness...........	Weight, in grains, abraded on grindstone under the stated conditions.	128
Porosity	Per cent of water absorbed in 24 hours when thoroughly dried.	0.145
Corrodibility......	Per cent of weight lost in acid solution in 63 hours.	0.446

The conclusion is hence apparent that the greater the strength, the greater, also, is the softness or capacity for abrasion. This result was unexpected, and can not, of course, be laid down as a general rule applicable to building stones, or even to slates which differ greatly in structure. The capacity for abrasion here seems allied to toughness, or it denotes the lack of brittleness; but this relation certainly is not a general one, although it is true of the roofing slates here discussed, and also of others which the writer has investigated. The testimony of the quarrymen, moreover, as far as he has been able to obtain it, seems to verify the conclusion that in this slate region softness, strength, and toughness are qualities closely connected.

Similar comparisons may be made between strength and toughness, strength and corrodibility, and porosity and corrodibility. The conclusion is irresistible that these qualities are so connected that one may be taken as an approximate index of the others; and, after carefully considering the whole field, the writer does not hesitate to decide that the test for transverse strength is the one which is the most satisfactory for roofing slates, if only one test is to be made. It is one that can be made quickly and without expensive apparatus. The modulus of rupture is an absolute quantity independent of the size of the specimen, and it gives to the engineer a more definite idea of the quality of materials than do the figures indicating other properties. In making this test it will usually be easy to measure the deflections and thus obtain the means for comparing the toughness as well as the strength.

While the test for porosity is a valuable one, it is necessary that the specimens should be brought to the same degree of dryness by heating them for an entire day; and as the amount of water absorbed is only about one-fifth of 1 per cent, the weighing must be done with care. The test for corrodibility is also a good one, but precise weighing is also necessary. The tests for abrasion on a grindstone and for specific gravity appear lowest of all in practical value, and their use can not, in general, be recommended, the former being liable to be misinterpreted, and the latter not being sharply related, in this case at least, to the strength and weathering qualities.

Chemical analyses.—Although the interpretation of chemical analyses is, at best, imperfect and unsatisfactory, it was not thought advisable to entirely neglect them in this investigation. The physical properties being known, they may perhaps be in some measure accounted for by the chemical composition. Hence an analysis was made of a specimen of slate by Dr. Frederick Fox, instructor in chemistry in Lehigh University. The expense of chemical work is so great that an analysis of each specimen could not be undertaken, and accordingly B3 was selected as being an average sample in strength and weathering qualities. The complete analysis of the slates was not undertaken, this being a long and expensive operation, but such elements were determined as would probably afford indications, first, of its valuable qualities, and, secondly, of its injurious constituents. The following is the report of the chemical analysis:

Analysis of slate from Bangor, Pennsylvania.

	Per cent.
Silica (SiO_2)	56.97
Oxides of iron and aluminum (Fe_2O_3 Al_2O_3)	26.05
Carbonic acid (CO_2) and organic matter	7.14
Oxide of calcium (CaO), or lime	4.38
Oxide of magnesium (MgO)	2.69
Sulphur (S)	0.46
Oxides of sodium and potassium (by difference)	2.31
Manganese	Trace.
Total	100.00

The above are the substances actually determined in the chemical work. They do not, however, exist in these forms in the slate itself. Slate consists principally of silicates of iron and aluminum, with smaller proportions of silicates of sodium and potassium, together with carbonates of lime and magnesium and sulphide of iron as impurities. In the analysis the silicates are broken up into silica and oxides, and these separately determined. So the carbonate of lime is broken up into carbonic acid and oxide of calcium, and the latter determined.

Now, the valuable constituents of slate are the silicates of iron and aluminum, or the clay, this being inert and incorrodible. The percentage of this is easily computed from the chemical analyses to be as follows, which indicates the "Old Bangor" to be a very superior slate:

Silicates of iron and aluminum found in Old Bangor slate.

	Per cent.
Silicates of iron and aluminum	83.02

The injurious constituents in slate are the carbonates of lime and magnesia and the sulphide of iron, or iron pyrites. The carbonates are easily attacked and dissolved by water which has been rendered slightly acid by smoke, and the pyrites is apt to cause disintegration. The chemical analyses furnish the means of computing the carbonates, and the amount of pyrites is probably closely proportioned to that of the sulphur. The percentage of sulphur, however, is so small that its influence is probably slight. The computed percentages of carbonates are:

Carbonates found in Old Bangor slate.

	Per cent.
Carbonate of lime	7.82
Carbonate of magnesia	5.65
Total carbonates	13.47

Conclusions.—The above investigation seems to indicate the following conclusions regarding the roofing slates from the quarries of the Old Bangor Slate Company:

1. These roofing slates weigh about 173 pounds per cubic foot, and the best qualities have a modulus of rupture of from 7,000 to 10,000 pounds per square inch.
2. The stronger the slate, the greater is its toughness and softness and the less is its porosity and corrodibility.
3. Softness, or liability to abrasion, does not indicate inferior roofing slate; but, on the contrary, it is an indication of strength and good weathering qualities.
4. The strongest slate stands highest in weathering qualities, so that a flexural test affords an excellent index of all its properties, particularly if the ultimate deflection and the manner of rupture be noted.
5. The strongest and best slate has the highest percentage of silicates of iron and aluminum, accompanied by moderate amounts of carbonates of lime and magnesia.
6. Chemical analyses give only imperfect conclusions regarding the weathering qualities of slate, and they do not satisfactorily explain the physical properties.
7. Architects and engineers who write specifications for roofing slate will probably obtain a more satisfactory quality if they insert requirements for a flexural test to be made on several specimens picked at random out of each lot.
8. Although the field of this investigation is probably not sufficiently extended to fully warrant the recommendation, it is suggested that such specifications should require roofing slates to have a modulus of rupture, as determined by the flexural test, greater than 7,000 pounds per square inch.

VERMONT.

The output increased from a valuation of $609,596 in 1896 to $695,815 in 1897.

Export trade was a very important element in the business of Vermont, as also in Pennsylvania, during 1897.

VIRGINIA.

The product in 1896 was valued at $107,863, in 1897 at $145,370. An increase is evident, and export trade is largely accountable for this, as in Vermont and Pennsylvania.

The following is an analysis of slate quarried by Messrs. Jno. R. Williams & Co. at their quarries at Arvonia, Virginia, by Henry Froehling, Ph. D.:

Analysis of slate from Arvonia, Virginia.

	Per cent.
Silica, SiO_2	60.65
Alumina, Al_2O_3	16.87
Ferri-oxide, Fe_2O_3	7.79
Manganese	Trace.
Lime, CaO	1.91
Magnesia, MgO	2.39
Carbon dioxide, CO_2	Trace.
Sulphur, S	.69
Potash, K_2O	3.80
Soda, Na_2O	2.18
Water and organic matter	3.63
Total	99.91

The sample dried at 212° F.

SANDSTONE.

PRODUCTION.

The following table shows the output of sandstone in the United States for the year 1897:

Sandstone production in 1897, by States.

State.	Value.	State.	Value.
Alabama	$3,000	Missouri	$57,583
Arizona	15,000	Montana	25,644
Arkansas	3,161	New Jersey	190,976
California	4,035	New York	544,514
Colorado	60,847	North Carolina	11,500
Connecticut	364,604	Ohio	1,600,058
Illinois	14,250	Pennsylvania	380,813
Indiana	35,561	Texas	30,030
Iowa	14,771	Utah	7,907
Kansas	20,953	Washington	16,187
Kentucky	40,000	West Virginia	47,288
Louisiana	8,000	Wisconsin	33,620
Massachusetts	194,684	Wyoming	11,275
Michigan	171,127	Total	4,065,445
Minnesota	158,057		

The following table gives the value of the sandstone output, by States, for the years 1890 to 1897:

Value of sandstone, by States, from 1890 to 1897.

State.	1890.	1891.	1892.	1893.
Alabama	$43,965	$30,000	$32,000	$5,400
Arizona	9,146	1,000	35,000	46,400
Arkansas	25,074	20,000	18,000	3,292
California	175,598	100,000	50,000	26,314
Colorado	1,224,098	750,000	550,000	126,077
Connecticut	920,061	750,000	650,000	570,346
Florida	(a)	....	....	....
Georgia	(a)	....	2,000	....
Idaho	2,490	....	3,000	2,005
Illinois	17,896	10,000	7,500	16,859
Indiana	43.983	90,000	80,000	20,000
Iowa	80,251	50,000	25,000	18,347
Kansas	149,289	80,000	70,000	24,761
Kentucky	117,940	80,000	65,000	18,000
Maryland	10,605	10,000	5,000	360
Massachusetts	649,097	400,000	400,000	223,348
Michigan	246,570	275,000	500,000	75,547
Minnesota	131,979	290,000	175,000	80,296
Missouri	155,557	100,000	125,000	75,701
Montana	31,648	35,000	35,000	42,300
Nevada	(a)	....	....	....
New Hampshire	3,750	....	....	....
New Jersey	597,309	400,000	350,000	267,514
New Mexico	186,804	50,000	20,000	4,922
New York	702,419	500,000	450,000	415,318
North Carolina	12,000	15,000	....	....
Ohio	3,046,656	3,200,000	3,300,000	2,201,932
Oregon	8,424	....	35,000	....
Pennsylvania	1,609,159	750,000	650,000	622,552
Rhode Island	(a)	....	....	....
South Dakota	93,570	25,000	20,000	36,165
Tennessee	2,722	....	....	....
Texas	14,651	6,000	48,000	77,675
Utah	48,306	36,000	40,000	136,462
Vermont	(a)	....	....	....
Virginia	11,500	40,000	....	3,830
Washington	75,936	75,000	75,000	15,000
West Virginia	140,687	90,000	85,000	46,135
Wisconsin	183,958	417,000	400,000	92,193
Wyoming	16,760	25,000	15,000	100
Total	10,816,057	8,700,000	8,315,500	5,295,151

(a) Sandstone valued at $20,199 was produced by Rhode Island, Nevada, Vermont, Florida, and Georgia together, and this sum is included in the total.

Value of sandstone, by States, from 1890 to 1897—Continued.

State.	1894.	1895.	1896.	1897.
Alabama	$18,100	$31,930	$48,000	$3,000
Arizona	....	20,000	10,000	15,000
Arkansas	2,365	13,228	1,400	3,161
California	10,087	11,933	7,267	4,035
Colorado	69,105	63,237	58,989	60,847
Connecticut	322,934	397,853	426,029	364,604
Georgia	11,300	....	1,250	....
Idaho	10,529	6,900	16,060	....
Illinois	10,732	6,558	15,061	14,250
Indiana	22,120	60,000	32,847	35,561
Iowa	11,639	5,575	12,351	14,771
Kansas	30,265	93,394	18,804	20,953
Kentucky	27,868	25,000	....	40,000
Louisiana	....	....	....	8,000
Maryland	3,450	16,836	10,713	....
Massachusetts	160,231	339,487	304,361	194,684
Michigan	34,066	159,075	111,321	171,127
Minnesota	8,415	74,700	202,900	158,057
Missouri	131,687	100,000	51,144	57,583
Montana	16,500	31,069	3,250	25,644
New Jersey	217,941	111,823	126,534	190,976
New Mexico	300	2,700	....	....
New York	450,992	415,644	223,175	544,514
North Carolina	....	3,500	13,250	11,500
Ohio	1,777,034	1,449,659	1,679,265	1,600,058
Pennsylvania	349,787	500,000	446,926	380,813
South Dakota	9,000	26,100	37,077	....
Tennessee	....	....	4,100	....
Texas	62,350	97,336	36,000	30,030
Utah	15,428	5,000	7,860	7,907
Virginia	2,258	....	....	....
Washington	6,611	14,777	11,090	16,187
West Virginia	63,865	40,000	24,693	47,288
Wisconsin	94,888	78,000	65,017	33,620
Wyoming	4,000	10,000	16,465	11,275
Total	3,955,847	4,211,314	4,023,199	4,065,445

Inspection of this table shows that the output has increased slightly over 1896, for which year the value was $4,023,199, while for 1897 it was $4,065,445.

THE SANDSTONE INDUSTRY IN THE VARIOUS STATES.

ALABAMA.

But little sandstone quarrying was done in 1897, but indications are more encouraging for 1898.

ARIZONA.

Production amounted to $15,000, a slight increase over 1896. A full description of the Flagstaff quarries was given in the report for 1896. This stone is making a good impression and has already been employed in the construction of a number of large buildings.

ARKANSAS.

But little was done in 1897; a number of quarries were shut down for the year or a large part of it.

CALIFORNIA.

Production was small in amount for 1897.

The following report regarding the sandstone quarried by the Farwell Stone Company, at their quarries at Niles, Alameda County, was made by Prof. E. W. Hilgard, of the University of California:

> I find it to be a sandstone consisting in the main of grains of quartz partly angular, partly rounded, scattering grains of black mica (biotite), and a few scattering grains of calcite and feldspar. These minerals are cemented together mainly by zeolitic cement, together with a purely siliceous one. The minerals of which this rock is composed are highly refractory to weathering and none of them are liable to change of color. None of the rock submitted contains any iron pyrites which might discolor or disintegrate it. The cementing substance resembles closely that of concrete made with hydraulic cement, and is therefore more liable to harden than to soften from exposure to the weather. From the chemical standpoint therefore I consider the rock a very durable one.

COLORADO.

The value of the output in 1896 was $58,989; in 1897, $60,847. Indications for the future are better on the whole than for several years past.

CONNECTICUT.

The value of output in 1896 was $426,029; the figure for 1897 was $364,604. There has evidently been a decline, but prospects for 1898 are said to be better. Most of the sandstone comes from the neighborhood of Portland, Cromwell, and just across the river from Middletown. A full and exhaustive statement of tests and analyses of the Portland sandstone quarried by the Brainerd, Shaler & Hall Quarry Company and the Middlesex Quarry Company was made in the report for 1896.

The stone quarried at East Haven is a rather unique sandstone, being composed of granitic constituents and requiring methods of quarrying resembling those applied to granite rather than ordinary sandstone. It is a hard, durable stone, used freely in New Haven and vicinity in buildings and in bridge work. A church at East Haven built of this material over a hundred years ago is apparently unimpaired to-day.

The sandstone industry of Connecticut has long been one of general interest because of the popularity of the Portland sandstone for use in fronts of pretentious buildings, notably residences in New York, Boston, Philadelphia, and other large Eastern cities. For quite a long period of years this stone was in favor among the wealthy classes, and was generally regarded as the correct thing for fronts, and as an unmistakable indication of the financial and social standing of the occupant of the brownstone front.

At present there is some reaction in the leading cities in favor of lighter colored and less somber-looking stone, but in spite of this the Portland stone is still in demand in connection with light-colored material, as it forms, when so used, an agreeable contrast, bringing out in relief the light and dark stone to the advantage of both, and producing a general effect which is an improvement upon either stone by itself. It is conceded by builders generally that Portland stone should invariably be laid "on the bed" in buildings and not "on edge," if the maximum durability is to be secured. Experience has shown a decided difference in the weathering qualities of this sandstone, according to the manner of laying the stone on bed or edge. The producers of the stone themselves insist that this distinction should be observed, in justice to the stone, as well as to the builder and owner of the edifice.

The quarries at Portland and vicinity are worked upon a large scale, and by firms possessing ample capital and extensive plant. There is a very large percentage of waste material handled at these quarries, and much care is exercised in selecting the best material only for use in building. This fact necessitates handling enormous quantities of stone, and to do this economically the best and most modern devices for lifting and shifting large masses must be used, so that liberal capital must be invested or the work becomes too expensive to pay. The Brainerd, Shaler & Hall Quarry Company represents the consolidation of a number of concerns with extensive capital. The Middlesex Quarry Company is another important concern. Private railways, powerful derricks, and what is probably the largest traveler in the country, if not in the world, are to be found here.

A slaty-looking material, known to the quarrymen as "shell," is abundant and must be avoided; the same material occurs in the sandstone at East Long Meadow, Massachusetts.

The method of quarrying is simple, and adapted to the production of large blocks at a minimum of expense. Large blocks are loosened out by the Knox system of blasting, and then men working together in gangs pry the blocks out so that a chain may be hooked around them, by which they are hoisted from the quarry by derricks. The teams of oxen formerly used for hauling stone have almost entirely disappeared, their work now being done by steam. The stone is shipped largely in the rough. The work of squaring blocks is done by dealers using saws and chilled iron as the abrasive material, although a few diamond saws are also in use. Rubbing is accomplished by lowering the stone upon a revolving iron disk, upon which sand and water are continually fed.

ILLINOIS.

The production of sandstone was about the same in point of value for the last two years. Comparatively little sandstone is produced. Most of the quarries of the State produce limestone, and, as may be seen from the limestone report, the output is very large.

INDIANA.

Sandstone quarrying in Indiana is, as compared with the limestone industry of the State, of much less importance. The value of the sandstone output in 1897 was $35,561, a slight increase over 1896.

IOWA.

Limestone quarrying in this State constitutes the chief part of the stone industry of the State, sandstone production being comparatively small. The value of the sandstone product in 1897 was $14,771. Most of the quarries of the State are small, but there is a large number of them.

KANSAS.

The output from a number of comparatively small quarries in 1897 amounted to $20,953, slightly more than in 1896.

KENTUCKY.

Sandstone valued at $40,000 was produced in 1897.

The following is an analysis of the bluestone quarried by Mr. John M. Mueller at his quarries in Rockcastle County, by Mr. W. M. Mew, analytical chemist:

Analysis of sandstone from Rockcastle County, Kentucky.

	Per cent.
Silica, SiO_2	91.075
Oxide of iron and alumina, $F_2O_3+Al_2O_3$	4.920
Lime, CaO	1.187
Water	2.361
Total	99.543

The stone absorbs 3 per cent of water.

The same stone was tested at the Watertown Arsenal by Capt. Ira MacNutt, with the following results:

Tests of sandstone from Rockcastle County, Kentucky.

Test No.	Marks.	How tested.	Dimensions.			Sectional area.	Ultimate strength.	
			Height.	Compressed surface.			Total.	Per sq. in.
			Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*
5485	Upper ledge.	On bed..	2.01	2.00	2.02	4.04	61,250	15,160
5486	.....do	On edge.	2.03	2.00	2.02	4.04	49,320	12,208
5487	Lower ledge.	On bed..	2.03	2.01	2.01	4.04	61,050	15,111
5488	.....do	On edge.	2.03	2.00	2.00	4.00	49,900	12,475

Crack appeared in No. 5486 at 47,500 pounds.
Crack appeared in No. 5488 at 43,000 pounds.
Fractures all pyramidal.

LOUISIANA.

A small quantity of sandstone was quarried for riprap in jetty construction.

MASSACHUSETTS.

There was a decided falling off in sandstone production, namely, from $304,361 in 1896 to $194,684 in 1897. The most important quarries are those of East Long Meadow, the output of which is well and favorably known as the result of years of experience in building.

The following is a statement of tests made on the sandstone quarried by Messrs James & Marra at their quarries at East Long Meadow, by Maj. J. W. Reilly at the Watertown Arsenal:

Tests of sandstone from East Long Meadow, Massachusetts.

[Compressed surfaces faced with plaster of paris.]

No. of test.	Marks.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
		Height.	Compressed surface.				Total.	Per square inch.
		Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
9425	Kibbe red stone............	4.97	4.95	4.98	24.65	299,000	301,100	12,215
9426	Long Meadow brown stone.	4.89	5.03	4.92	24.75	304,800	305,150	12,330

The following tests and analyses of sandstone from the three quarries, Worcester, Kibbe, and Maynard, operated by Messrs. Norcross Brothers at East Long Meadow, Massachusetts, were submitted by this firm. The physical tests were made by Lieut. Col. F. H. Parker at the Watertown Arsenal, and are as follows:

Tests by compression of two 6-inch cubes of sandstone from Worcester quarry.

[The specimens were tested between flat steel platforms. Their bed surfaces were faced with a thin (.02″) coating of plaster of paris to secure even bearings in the testing machine.]

No. of test.	Dimensions.			Sectional area.	Ultimate strength.	
	Length.	Bed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Square inches.*	*Pounds.*	*Pounds.*
4 96	6.16	6.03	6.02	36.30	420,900	11,595
4097	6.13	6.02	6.01	36.18	371,800	10,276

A single pyramid was developed by the fracture of these specimens, the bed surfaces forming the bases of the pyramids.

The following analysis of sandstone from the same quarry, Worcester, was made by L. P. Kinnicutt, Ph. D., at the laboratory of the Worcester Polytechnic Institute:

Analysis of sandstone from Norcross Brothers' Worcester quarry.

	Per cent.
Silica, SiO_2	88.89
Alumina, Al_2O_3	5.95
Iron oxide, F_2O_3	1.79
Manganese dioxide, MnO_2	0.41
Lime, CaO	0.27
Potassa and soda, $K_2O + Na_2O$	0.86
Carbonic acid, water, and loss	1.83
Total	100.00

Tests by compression of two 6-inch cubes of red sandstone from Messrs. Norcross Brothers' Kibbe quarry.

[The specimens were tested between flat steel platforms. Their bed surfaces were faced with a thin (0.02″) coating of plaster of paris to secure even bearings in the testing machine.]

Number of test.	Dimensions.			Sectional area.	Ultimate strength.	
	Length.	Bed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Square inches.*	*Pounds.*	*Pounds.*
3337	6.00	5.97	6.00	35.82	452,000	12,619
3338	6.02	5.97	5.98	35.70	459,600	12,874

Cracks appeared in cube No. 3337 under 451,000 pounds pressure. A single pyramid was developed by the fracture of this specimen. Cracks appeared in cube No. 3338 under 435,000 pounds pressure, the specimen developing a double pyramidal fracture, the bed surfaces forming the bases of the pyramids.

The following analysis of sandstone from Kibbe quarry was made by Prof. C. F. Chandler, of school of mines, Columbia University, New York:

Analysis of sandstone from Norcross Brothers' Kibbe quarry.

	Per cent.
Silica, SiO_2	81.38
Alumina, Al_2O_3	9.44
Oxide of iron, Fe_2O_3	3.54
Lime, CaO	.76
Oxide of manganese	.11
Magnesia, MgO	.28
Carbonic acid, water, and loss	4.49
Total	100.00

Tests by compression of two 6-inch cubes of sandstone from Messrs. Norcross Brothers' Maynard quarry.

[The specimens were tested between flat steel platforms. Their bed surfaces were faced with a thin (0.02″) coating of plaster of paris to secure even bearings in the testing machine.]

Dimensions.			Sectional area.	Ultimate strength.	
Length.	Bed surface.			Total.	Per square inch.
Inches.	*Inches.*	*Inches.*	*Square inches.*	*Pounds.*	*Pounds.*
6.16	6.03	6.02	36.30	371,100	10,223

A single pyramid was developed by the fracture of these specimens, the bed surfaces forming the bases of the pyramids.

The following analysis of Maynard quarry sandstone was made by L. P. Kinnicutt, Ph. D.:

Analysis of sandstone from Norcross Brothers' Maynard quarry.

	Per cent.
Silica, SiO_2	79.38
Iron oxide, Fe_2O_3	2.43
Alumina, Al_2O_3	8.75
Lime, CaO	2.57
Soda and potassa, Na_2O and K_2O	4.08
Carbonic acid and water loss	2.79
Total	100.00

MICHIGAN.

The value of the output increased from $111,321 in 1896 to $171,127 in 1897. The sandstone of Michigan is coming more and more into use over a considerable area of the United States.

The following physical tests of stone quarried by the Kerber-Jacobs Redstone Company were made by Maj. J. W. Reilly at Watertown Arsenal:

Tests of Michigan sandstone.

Test number.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Height.	Compressed surface.				Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
7823..	2.00	2.03	2.03	4.12	24,800	24,800	6,019
7824..	2.00	2.04	2.02	4.12	21,700	21,820	5,296
7825..	2.00	2.01	2.02	4.06	27,510	27,510	6,776
7826..	2.00	2.01	2.00	4.02	27,440	27,440	6,826
7827..	1.99	2.03	2.02	4.10	24,550	24,550	5,988
7828..	2.00	2.02	2.02	4.08	24,980	24,980	6,123

Pyramidal fractures.

MINNESOTA.

Production fell from a valuation of $202,900 in 1896 to $158,057 in 1897.

The following is an analysis of the sandstone known as Kettle River sandstone, quarried by the Minnesota Sandstone Company at their quarries at Sandstone, Minnesota, by Prof. N. H. Winchell:

Analysis of sandstone from Sandstone, Minn.

	Per cent.
Water	0.00
Silica, SiO_2	98.69
Alumina, Al_2O_3	1.06
Iron oxide	Slight trace.
Calcium oxide, CaO	.42
Magnesium oxide, MgO	.01
Sodium oxide, Na_2O	.17
Total	100.35

The following test of crushing strength was made at one of the United States arsenals:

Crushing-strength test of sandstone quarried by Minnesota Sandstone Company.

[Four inch cubes.]

No.	Total pressure.	Pressure per square inch.
	Pounds.	*Pounds.*
1	204,100	12,295
2	109,900	12,799

MISSOURI.

The value of the output in 1896 was $51,144; in 1897, $57,583. When the general business interests of the country have again reached normal conditions production will probably increase.

NEW JERSEY.

The value of the output in 1896 was $126,534; that of the product in 1897 was $190,976. An increase in output is evident, and the industry seems to be on a more substantial basis than for several years.

NEW YORK.

The sandstone industry in New York State is of special interest on account of the fine quality of the stone taken from a number of its prominent quarries. The stone is well known to builders and experts. The output of 1896 was valued at $223,175, while that of 1897 amounted in value to $544,514.

The increase in output is due in some degree to the use of stone in repairs and changes in the Erie Canal.

The following is an analysis of the sandstone quarried by Mr. L. W. Hotchkiss at his quarries at Lewiston, Niagara County, made by Messrs. Stillwell and Gladdig, chemists, of New York City:

Analysis of sandstone from Lewiston, Niagara County, New York.

	Per cent.
Silica, SiO_2	98.6
Oxide of iron, Fe_2O_3	0.6
Total	99.2

The following test of the stone quarried by the Genesee Valley Blue Stone Company at their quarries at Portage, New York, was made at the Watertown Arsenal by Maj. F. H. Parker:

Tests of stone from Portage, New York.

[Compression faces dressed, sides rough.]

Specimen did not have parallel compression faces; and required 0.08-inch packing under one corner to secure even bearings in testing machines.

Sectional area, 5.04 square inches.

At 502,000 pounds stone began to crack at one corner. Gradual opening of cracks along two edges after passing the above load.

Ultimate strength, 711,100 pounds = 14,110 pounds per square inch.

Burst suddenly into fragments under the maximum load. One principal piece pyramidal shaped.

The following tests of bluestone quarried by the Warsaw Bluestone Company at their quarries at Warsaw, New York, were made by Lieut. Col. D. W. Flagler at the Watertown Arsenal:

Tests of bluestone from Warsaw, New York.

[Stones tested on bed.]

Test No.	Weight.			Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Total.		Per cubic foot.	Height.	Compressed surface.				Total.	Per square inch.
	Lbs.	*Oz.*	*Pounds.*	*Inches.*	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
6648	11	7½	158.2	5.01	5.00	5.00	25.00	499,200	499,200	19,968
6649	11	6	157.3	5.00	5.00	5.00	25.00	476,900	476,900	19,076
6650	11	7½	157.3	5.01	5.02	5.01	25.15	478,400	478,400	19,022

Pyramidal fractures; stones burst into fragments when the maximum load was reached.

NORTH CAROLINA.

The output of sandstone in 1897 was valued at $11,500. This is slightly below the value of the product of 1896.

OHIO.

The sandstone industry in Ohio is a large and important one. The value of the output in 1892 was $3,300,000; since that year, however, owing to the general depression in business, this high figure has not again been reached. The value of the output in 1897 was $1,600,058.

The stone is used for a wide range of purposes, including building, flagging, curbing, grindstones, whetstones, etc.

The following is the statement of an analysis of the sandstone quarried by Messrs. Reynolds Brothers, at their quarries at Freeport, Ohio, by Mr. Charles D. Rawling, chemist, of Wheeling, West Virginia:

Analysis of Freeport, Ohio, sandstone.

	Per cent.
Dried at 100° C.	
Silica, SiO_2	95.17
Alumina, Al_2O_3	.73
Ferric oxide, Fe_2O_3	2.53
Lime, CaO	.36
Magnesia, MgO	Trace.
Loss on ignition	1.17
Total	99.96
Water absorbed	6.08

The following tests of sandstone quarried by Mr. F. C. Neeb at his quarries at Lancaster, Fairfield County, were made by Mr. M. J. Becker, chief engineer of the Pittsburg, Cincinnati, Chicago and St. Louis Railroad:

Six inch cubes were tested.

Tests of sandstone from Lancaster, Ohio.

No. of test.	Dimensions.			Sectional area.	Ultimate strength.	
	Height.	Compressed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*
1	5.9	6	5.9	35.4	210,600	5,950
2	5.8	5.85	5.85	34.22	231,400	6,762

The following analyses of the same stone were made by Mr. Hugo Blanck, chemist, of Pittsburg, Pennsylvania:

Analyses of sandstone from Lancaster, Ohio.

	Yellow (No. I).	Pale (No. II).
	Per cent.	*Per cent.*
Silica, SiO_2	96.822	97.762
Alumina, Al_2O_3	.505	.731
Oxide of iron	.670	.510
Lime, CaO	.040	.122
Magnesia, MgO	.005	.003
Water, H_2O	1.281	.511
Total	99.323	99.639

OREGON.

This State produced sandstone to the value of $35,000 in 1892, but since that time little has been done. The value of the output in 1897 was very small.

The following is a statement of the results of analysis and physical test of sandstone quarried by the Victor Sandstone Company at their quarries at Chitwood, Lincoln County, by Maj. J. W. Reilly at the Watertown Arsenal:

Analysis of Chitwood (Oregon) sandstone.

	Per cent.
Silica, SiO_2	72.45
Oxide of iron	10.80
Alumina, Al_2O_3	12.60
Lime, CaO	4.10
Magnesia, MgO	Trace.
Total	99.95

Compression test.

Sectional area, 4.03×4.20×6.07=24.46 square inches.
First crack at 145,000 pounds.
Ultimate strength, 153,700=6,284 pounds per square inch; pyramidal fracture.

PENNSYLVANIA.

The value of the sandstone output in 1896 was $446,926; the corresponding figure for 1897 was $380,813. A full account of the sandstone of Pennsylvania was published in the report for 1896.

The following is an analysis of sandstone quarried by Mr. Webster Keasey at his quarries at Rough Run, Pennsylvania, by Mr. James O. Handy, chemist, of Pittsburg, Pennsylvania:

Analysis of Rough Run sandstone.

	Per cent.
Silica, SiO_2	97.96
Alumina, Al_2O_3	1.15
Ferric oxide, Fe_2O_3	.11
Water and organic matter	.54
Alkalies	.24
Total	100.00

The following analysis of stone quarried by the Edge Hill Mica Schist Company, of Edge Hill, Pennsylvania, was made by the chemical department of the Pennsylvania Steel Company, of Steelton, Pennsylvania:

Analysis of sandstone from Edge Hill, Pennsylvania.

	Per cent.
Silica, SiO_2	89.00
Alumina, Cl_2O_3	6.83
Ferric oxide, Fe_2O_3	2.21
Lime, CaO	0.07
Magnesia, MgO	0.16
Alkalies (oxides of sodium and potassium)	1.73
Total	100.00

SOUTH DAKOTA.

Very little sandstone was quarried during 1897.

The following tests of sandstone quarried by the Baker Quarry Company, at their quarries at Rapid City, were made by Mr. William F. M. Goss, at Purdue University:

Tests of sandstone from Rapid City, South Dakota.

Kind of stone.	Area.	Total crushing strength.	Strength per square inch.
	Sq. in.	*Pounds.*	*Pounds.*
Gray	4.42	50,618	11,452
White	4.40	31,030	7,052
Red	4.14	25,320	6,116
Buff	4.34	39,220	9,037
Variegated	4.14	36,855	8,902
Brown	4.43	25,825	5,829

TENNESSEE.

Almost nothing was done in sandstone quarrying during the past year.

TEXAS.

The value of the sandstone output of 1897 was about the same as in 1896; for 1897 the value was $30,030.

UTAH.

A small output was secured during the year. The following tests of crushing strength were made at the testing laboratory of the University of Illinois.

Tests of sandstone from Utah.

[Two-inch cubes tested.]

Kind of stone.	Area.	Total stress.	Crushing strength per square inch.
	Sq. in.	*Pounds.*	*Pounds.*
Gray	4	16,800	4,200
Red	4	34,550	8,638

VIRGINIA.

Very little sandstone was quarried in 1897.

WASHINGTON.

Production increased from $11,090 in 1896 to $16,187 in 1897.

The following tests of sandstone, known as Bellingham Bay stone, from quaries known as Chuckanut quarries, operated by Mr. Henry Roeder, of Chuckanut, Washington, were made by Maj. J. W. Reilly, of Watertown Arsenal:

Tests of sandstone from Chuckanut, Washington.

[Compressed surfaces faced with plaster of paris to secure even bearings in the testing machine.]

Test No.	Dimensions.			Sectional area.	First crack.	Untimate strength.	
	Height.	Compressed surface.				Total.	Per sq. in.
	Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
7178	3.99	4.22	4.20	17.72	179,000	182,100	10,276
7179	4.09	4.13	4.20	17.35	183,000	221,900	12,790
7180	4.20	4.21	4.23	17.81	192,000	197,700	10,780

WEST VIRGINIA.

Production increased from a valuation of $24,693 in 1896 to $47,288 in 1897. Business is generally reported as improving throughout the State.

WISCONSIN.

The value of the output in 1896 was $65,017; in 1897, $33,620.

The following analysis of the sandstone quarried by the Prentice Brownstone Company at their quarries at Ashland, Wisconsin, was made by Prof. C. F. Chandler, of Columbia University, New York City:

Analysis of sandstone quarried by Prentice Brownstone Company, Ashland, Wisconsin.

	Per cent.
Silica, SiO_2	91.40
Ferric oxide, Fe_2O_3	2.00
Alumina, Al_2O_3	3.53
Lime, CaO	.25
Magnesia, MgO	None.
Potash, K_2O	2.36
Soda, Na_2O	.14
Sulphur	None.
Carbon dioxide, CO_2	None.
Moisture	.05
Total	99.73

WYOMING.

Production fell off from $16,465 in 1896 to $11,275 in 1897.

The crushing strength of Rawlins gray sandstone is reported from a Government test to be 10,833 pounds to the square inch.

LIMESTONE.

PRODUCTION.

The following table shows the production of limestone in the United States in 1897. The total valuation, $14,822,661, exceeds that of 1896 by $1,800,024. This is a very substantial gain, but in view of the increase which has marked the production of other kinds of stone it is not at all surprising and is a very satisfactory indication of returning prosperity in stone production:

Production of limestone in 1897, by States.

State.	Lime.	Building and roadmaking.	Flux.	Total.
Alabama	$157,842	$25,752	$38,217	$221,811
Arizona	11,522			11,522
Arkansas	30,890	13,332		44,222
California	277,104	17,894	13,927	308,925
Colorado	11,970	2,971	64,315	79,256
Connecticut	177,702		708	178,410
Florida	16,636	2,253		18,889
Georgia	27,000		5,000	32,000

Production of limestone in 1897, by States—Continued.

State.	Lime.	Building and roadmaking.	Flux.	Total.
Idaho	$12,760	$2,778	....	$15,538
Illinois	228,220	1,213,291	$41,646	1,483,157
Indiana	173,750	1,716,461	122,397	2,012,608
Iowa	104,163	376,409	....	480,572
Kansas	8,971	199,918	....	208,889
Kentucky	6,583	27,943	6,289	40,815
Maine	742,877	....	....	742,877
Maryland	182,441	16,924	....	199,365
Massachusetts	113,809	11,726	973	126,508
Michigan	145,280	67,534	2,363	215,177
Minnesota	61,187	175,210	....	236,397
Missouri	404,885	605,445	7,872	1,018,202
Montana	12,750	....	24,550	37,300
Nebraska	400	21,446	20,513	42,359
New Jersey	108,195	2,170	31,281	141,646
New York	555,050	1,074,214	68,516	1,697,780
Ohio	877,167	462,209	147,174	1,486,550
Pennsylvania	1,038,723	580,383	708,764	2,327,870
Rhode Island	11,555	....	....	11,555
South Carolina	30,000	....	....	30,000
South Dakota	1,895	2,000	....	3,895
Tennessee	76,037	35,609	2,128	113,774
Texas	21,862	14,816	20,580	57,258
Utah	3,877	116	5,257	9,250
Vermont	164,960	697	....	165,657
Virginia	101,424	27,852	63,696	192,972
Washington	122,317	....	4,560	126,877
West Virginia	57,328	3,183	1,035	61,546
Wisconsin	311,355	328,759	1,118	641,232
Total	6,390,487	7,029,295	1,402,879	14,822,661

The following table shows the value of limestone, by States, since 1890:

Value of limestone, by States, from 1890 to 1897.

State.	1890.	1891.	1892.	1893.
Alabama	$324, 814	$600, 000	$325, 000	$205, 000
Arizona	(a)	....	....	15, 000
Arkansas	18, 360	20, 000	18, 000	7, 611
California	516, 780	400, 000	400, 000	288, 626
Colorado	138, 091	90, 000	100, 000	60, 000
Connecticut	131, 697	100, 000	95, 000	155, 000
Florida	(a)	....	....	35, 000
Georgia	(a)	....	....	34, 500
Idaho	28, 545	....	5, 000	1, 000
Illinois	2, 190, 607	2, 030, 000	3, 185, 000	2, 305, 000
Indiana	1, 889, 336	2, 100, 000	1, 800, 000	1, 474, 695
Iowa	530, 863	400, 000	705, 000	547, 000
Kansas	478, 822	300, 000	310, 000	175, 173
Kentucky	303, 314	250, 000	275, 000	203, 000
Maine	1, 523, 499	1, 200, 000	1, 600, 000	1, 175, 000
Maryland	164, 860	150, 000	200, 000	....
Massachusetts	119, 978	100, 000	200, 000	156, 528
Michigan	85, 952	75, 000	95, 000	53, 282
Minnesota	613, 247	600, 000	600, 000	208, 088
Missouri	1, 859, 960	1, 400, 000	1, 400, 000	861, 563
Montana	24, 964	....	6, 000	4, 100
Nebraska	207, 019	175, 000	180, 000	158, 927
New Jersey	129, 662	100, 000	180, 000	149, 416
New Mexico	3, 862	2, 000	5, 000	....
New York	1, 708, 830	1, 200, 000	1, 200, 000	1, 103, 529
Ohio	1, 514, 934	1, 250, 000	2, 025, 000	1, 848, 063
Oregon	(a)	....	....	15, 100
Pennsylvania	2, 655, 477	2, 100, 000	1, 900, 000	1, 552, 336
Rhode Island	27, 625	25, 000	30, 000	24, 800
South Carolina	14, 520	50, 000	50, 000	22, 070
South Dakota	(a)	....	....	100
Tennessee	73, 028	70, 000	20, 000	126, 089
Texas	217, 835	175, 000	180, 000	28, 100
Utah	27, 568	....	8, 000	17, 446
Vermont	195, 066	175, 000	200, 000	151, 067
Virginia	159, 023	170, 000	185, 000	82, 685
Washington	231, 287	25, 000	100, 000	139, 862
West Virginia	93, 856	85, 000	85, 000	19, 184
Wisconsin	813, 963	675, 000	675, 000	543, 283
Wyoming	(a)	....	....	....
Total	19, 095, 179	15, 792, 000	18, 342, 000	13, 947, 223

a Limestone valued at $77,935 was produced in Oregon, Georgia, Florida, Arizona, South Dakota, and Wyoming. The value is included in the total.

Value of limestone, by States, from 1890 to 1897—Continued.

State.	1894.	1895.	1896.	1897.
Alabama	$210,269	$222,424	$180,921	$221,811
Arizona	19,810	24,159	18,470	11,522
Arkansas	38,228	47,376	30,708	44,222
California	288,900	322,211	143,865	308,925
Colorado	132,170	116,355	65,063	79,256
Connecticut	204,414	154,333	138,945	178,410
Florida	30,639	10,550	16,982	18,889
Georgia	32,000	12,000	29,081	32,000
Idaho	5,315	7,829	5,662	15,538
Illinois	2,555,952	1,687,662	1,261,359	1,483,157
Indiana	1,203,108	1,658,976	1,658,499	2,012,608
Iowa	616,630	449,501	410,037	480,572
Kansas	241,089	316,688	158,112	208,889
Kentucky	113,934	154,130	135,967	40,815
Maine	810,089	700,000	608,077	742,877
Maryland	350,000	200,000	264,278	199,365
Massachusetts	195,982	75,000	118,622	126,508
Michigan	336,287	424,589	109,427	215,177
Minnesota	291,263	218,733	228,992	236,397
Missouri	578,802	897,318	802,968	1,018,202
Montana	92,970	95,121	83,927	37,300
Nebraska	8,228	7,376	10,655	42,359
New Jersey	193,523	150,000	134,213	141,646
New Mexico	4,910	3,375	....	....
New York	1,378,851	1,043,182	1,591,966	1,697,780
Ohio	1,733,477	1,568,713	1,399,412	1,486,550
Oregon	....	970	1,600	....
Pennsylvania	2,625,562	3,055,913	2,104,774	2,327,870
Rhode Island	20,433	....	11,589	11,555
South Carolina	25,100	....	26,000	30,000
South Dakota	3,663	4,000	3,126	3,895
Tennessee	188,664	156,898	157,176	113,774
Texas	41,526	62,526	77,252	57,258
Utah	23,696	22,503	9,358	9,250
Vermont	408,810	300,000	147,138	165,657
Virginia	284,547	268,892	182,640	192,972
Washington	59,148	75,910	83,742	126,877
West Virginia	43,773	42,892	59,113	61,546
Wisconsin	798,406	750,000	552,921	641,232
Wyoming	....	650	....	....
Total	16,190,118	15,308,755	13,022,637	14,822,661

THE LIMESTONE INDUSTRY IN INDIVIDUAL STATES.

The following is a consideration of the limestone industry in the various productive States:

ALABAMA.

Production increased from a value of $180,921 in 1896 to $221,811 in 1897. The increase was due to a greater production of lime and of flux for blast furnaces. The amount used for building and road making declined.

The following analysis of lime made from limestone quarried by the Longview Lime Works at their quarries at Longview, Alabama, was made by Mr. William C. Stubbs, Director of the Louisiana Sugar Experiment Station, of New Orleans:

Analysis of lime from Longview, Alabama.

	Per cent.
Insoluble matter	0.18
Lime, CaO	98.44
Magnesia, MgO	.98
Peroxide of iron Alumina	.26
Carbonic acid, Co_2	.32
Total	100.18

Dr. W. B. Phillips, chemist, of Birmingham, Alabama, reports that the limestone quarried by Mr. A. P. Birch, of Blount Springs, contains 99.10 per cent of calcium carbonate and less than 0.5 per cent of silica, the remainder being oxides of iron and alumina.

Mr. Alfred D. Brainerd, chemist, of Birmingham, Alabama, made the following analysis of lime from stone quarried by the Standard Lime Company at their quarries at Fort Payne, Alabama:

Analysis of lime from Fort Payne, Alabama.

	Per cent.
Lime, CaO	96.1128
Silica, SiO_2	1.6900
Magnesia, MgO	.1058
Phosphorus	.0554
Phosphoric acid, P_2O_5	.0126
Sulphur	.0192
Sulphuric acid, SO_3	.0048
Binoxide manganese	Trace.
Undetermined and water	1.9994
Total	100.0000

The following table represents the analyses of a number of Alabama limestones:

Analyses of limestone quarried in Alabama.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.									Total.
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Siliceous matter insoluble in acids.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Silica, SiO_2.	Carbon dioxide, CO_2.	Ferric oxide, Fe_2O_3.	
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Anniston Lime Works Co.	Anniston..	Etowah	Wm. Makemson, Anniston, Ala.	98.76	Trace	0.36	......	......	......	0.74	......	......	99.86
Longview Lime Works (No. 1).	Longview.	Shelby......	Eugene A. Smith, State geologist.	99.11	0.75	0.13	0.39	......	......	......	......	......	100.38
Longview Lime Works (No. 2).	.....do	.....do	.....do	99.16	0.75	Trace	0.15	......	......	......	......	......	100.06
Longview Lime Works (lime).	.....do	.....do	A. L. Metz, chemist Louisiana State Board of Health.	1.55	0.56	0.21	0.37	97.30	......	......	......	......	99.99
Franklin Quarry Co.	Russellville.	Franklin	J. C. Foster...........	97.00	1.40	0.70	......	......	......	0.90	......	......	100.00
T. L. Fossick & Co.	Sheffield ..	.....do	Chemist of Watertown Arsenal, Nov. 20, 1895.	......	......	......	......	54.20	1.23	0.50	42.61	1.45	99.99
Shelby Iron Co...	Shelby....	Shelby	C. F. Chandler, of New York.	98.91	0.58	0.63	......	......	......	0.10	......	......	100.22

ARIZONA.

There was a slight falling off in production in 1897, but it is hardly significant, as the industry in this State is as yet small at best.

ARKANSAS.

Production increased from $30,708 in 1896 to $44,222 in 1897.

The following analysis of the stone quarried by Mr. Mark Liles, at his quarries at Beaver, was made at the Navy Department at Washington, D. C.:

Analysis of limestone from Beaver, Arkansas.

	Per cent.
Silica, SiO_2	8.66
Oxides of iron and aluminum	4.77
Calcium carbonate, $CaCO_3$	48.48
Magnesium carbonate, $MgCO_3$	33.58
Calcium sulphate, $CaSO_4$	.42
Water alkalies, etc	4.09
Total	100.00

The following analysis of stone quarried by the Crescent White Lime Works, at their quarries at Johnson, was made by Prof. G. L. Teller, of the Arkansas Industrial Institute, at Fayetteville:

Analysis of limestone from Johnson, Arkansas.

	Per cent.
Material insoluble in acid	0.39
Oxides of iron and aluminum	.17
Calcium carbonate, $CaCO_3$	99.34
Moisture	.10
Total	100.00

The crushing strength was found to be 15,500 pounds to the square inch, by Professor Martin, of the same institution.

CALIFORNIA.

A decided increase in output marks 1897 as compared with 1896 in California. The value of the product in the former year was $143,865; in 1897 it was $308,925. Stone production all over the State has very materially improved during the past year.

COLORADO.

The value of the output in 1896 was $65,063; the figure for 1897 was $79,256. A slight increase is evident.

CONNECTICUT.

Production increased from a valuation of $138,945 in 1896 to $178,410 in 1897. Practically all the product was burned into lime, of which the above figures represent the value.

The following is an analysis of limestone quarried by Messrs. Canfield Brothers, of East Canaan, made at the Connecticut Agricultural Experiment Station:

Analysis of limestone from East Canaan, Connecticut.

	Per cent.
Matter insoluble in acid	0.48
Oxides of iron and aluminum	.20
Lime, CaO	31.31
Magnesia, MgO	21.03
Carbon dioxide, CO_2	46.98
Total	100.00

FLORIDA.

This State produced very little or no stone of any kind except coquina until a few years ago. In 1896 the value of the limestone output was $16,982; in 1897 $18,889.

GEORGIA.

Production increased somewhat in 1897, the value for this year being $32,000. The following analyses of limestone quarried by the A. O. Ladd Lime Works at their quarries at Bartow, and of the lime made from it, were made by Mr. N. P. Pratt, formerly State Mineralogist:

Analysis of lime from Bartow, Georgia.

	Per cent.
Lime, CaO	34.070
Magnesia, MgO	55.736
Alumina and iron oxide	1.236
Silica, SiO_2	7.252
Moisture	1.622
Total	99.916

Analysis of limestone from Bartow, Georgia.

	Per cent.
Calcium carbonate, $CaCO_3$	56.02
Magnesium carbonate, $MgCO_3$	38.43
Alumina and iron oxide	1.50
Silica, SiO_2	1.94
Moisture	0.00
Total	97.89

IDAHO.

Production increased from a valuation of $5,662 in 1896 to $15,538 in 1897.

ILLINOIS.

The limestone industry in Illinois has always been a large and important one. A few years ago the State stood first in output of limestone for building, but in 1896 and 1897 Indiana has taken first place. Most of the limestone produced in Illinois goes for building purposes. Full accounts of the quarrying operations at the Lemont and Joliet quarries have been given in former reports. The value of the product in 1897 was $1,483,157; in 1896 the corresponding figure was $1,261,359.

The following is a partial analysis of the stone quarried by the Kankakee Stone and Lime Company at their quarries at Kankakee, made by Mr. C. S. Robinson, chemist of Illinois Steel Company:

Analysis of limestone from Kankakee, Illinois.

	Per cent.
Silica, SiO_2	3.00
Oxides of iron and aluminum	2.50
Calcium oxide, CaO	30.45
Magnesium oxide, MgO	20.50
Phosphorus	.006

The following data in regard to the same stone were secured by Prof. C. W. Rolfe, of the Illinois State University, at Champaign:

Weight per cubic foot, 165.75 pounds; specific gravity, 2.65; crushing strength, 13,544 pounds to the square inch.

The following analysis of the limestone quarried by the Chicago Union Lime Works Company at their quarries in the limits of the city of Chicago was made by Mr. J. Blodget Britton, of the Ironmasters' Laboratory, of Warrenton, Virginia:

Analysis of Illinois limestone.

	Per cent.
Calcium carbonate, $CaCo_3$	52.76
Magnesium carbonate, $MgCo_3$	45.04
Oxides of iron and aluminum	1.48
Insoluble matter	.21
Water and loss	.51
Total	100.00

INDIANA.

The value of the limestone output in Indiana reached the highest figure since 1891, when it was very little more than that for the past year, for which the value was $2,012,608. Of course the Bedford oölitic limestone contributes the bulk of this output. The oölitic stone of Bedford was fully described, together with a consideration of methods of quarrying, occurrence, etc., in the report of 1896 by Messrs. T. C. Hopkins and C. E. Siebenthal. The latter gentleman has also contributed further information, which is presented further on in this report.

The crushing strength of the stone quarried by the Hollensbee Stone Company at their quarry at Westport, Indiana, was determined by General Q. A. Gillmore, U. S. A., and found to be 16,875 pounds per square inch.

A test was also made by General Gillmore of stone quarried by the Greensburg Limestone Company, at their quarry at Greensburg, Indiana, by which the average crushing strength of two 2-inch cubes was found to be 16,875 pounds per square inch.

Tests made by Mr. W. S. Blatchley, Indiana State geologist, of limestone from the quarries of the Acme Bedford Stone Company, at Clear Creek, Indiana, showed a crushing strength of specimen on natural bed of 11,770 pounds per square inch, and a crushing strength of specimen on edge of 10,119 pounds per square inch.

An analysis of this stone will be found in the following table of analyses of Indiana limestones.

Analyses of limestone quarried in Indiana.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.																	
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Silica, SiO_2.	Ferric oxide, Fe_2O_3.	Aluminum oxide, Al_2O_3.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Moisture and loss at 212° F.	Carbon dioxide, CO_2.	Loss and undetermined.	Silicious matter insoluble in acids.	Ferrous oxide, FeO.	Sulphuric anhydride, SO_3.	Sulphur, S.	Oxides of potassium and sodium.	Sodium oxide, Na_2O.	Manganese oxide.	Total.
				P. c.	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*	*P. c.*
Acme Bedford Stone Co.	Clear Creek.	Monroe.....	W. S. Blatchley, State geologist.	97.39	0.78	0.13	....	....	....	....	....	....	....	....	0.84	....	....	....	....	0.10	Trace	99.24
Bedford Quarries Co.	Bedford	Lawrence...	F. W. Clarke, chief chemist United States Geological Survey.	97.26	....	....	1.69	0.49	....	....	0.37	0.19	....	....	....	....	....	....	....	....	....	100
Bedford Portland Cement Co. (No. 1).	.....do	.....do	Prof. A. W. Smith, Case School of Applied Science, Cleveland, Ohio.	....	....	....	0.89	0.12	0.38	54.48	0.36	....	43.40	....	....	0.13	....	....	....	....	....	99.76
Bedford Portland Cement Co. (No. 2).	.....do	.....do	.....do	....	....	....	0.87	0.13	0.34	54.68	0.32	....	43.44	....	....	....	....	....	....	....	....	99.78
Baltos Land, Stone and Oil Co. (top rock).	Montpelier .	Blackford...	S. S. Gorby, State geologist.	....	....	4.70	2.75	....	....	42.92	3.88	0.95	41.20	2.81	....	....	0.79	....	....	....	....	100
Baltes Land, Stone and Oil Co. (intermediate rock).	.....do	.....do	.....do	....	....	5.25	2.68	....	....	42.55	4.40	1.25	39.10	3.68	....	....	1.09	....	....	....	....	100
Baltes Land, Stone and Oil Co. (bottom rock).	.....do	.....do	.....do	....	....	5.17	2.43	....	....	43.01	4.18	1.00	41.55	1.78	....	....	0.88	....	....	....	....	100
Huntington White Lime Co.	Huntington.	Huntington.	G. M. Levette, Indianapolis, Ind.	....	....	4.70	2.75	....	....	42.92	4.41	0.95	41.20	1.82	....	....	1.25	....	....	....	....	100
Defenbaugh & Smith (No. 1)	Kokomo	Howard	Grasselli Chemical Co.	98.66	....	....	0.24	Trace.	0.43	....	Trace.	....	....	....	....	....	....	....	....	....	....	99.33

Defenbaugh & Smith (No. 2).	.....do	.....do	.....do	97.05	.....	.....	1.62	0.16	0.60	.....	0.36	....	.....	....	....	....	....	Trace.	....	....	......	99.79
J. A. Derbyshire.	Laurel......	Franklin ...	Prof. W. A. Noyes, Rose Polytechnic Institute, Terre Haute, Ind.	43.67	20.60	11.01	21.51	....	..	......	......	1.89	.....	....	....	....	....	......	1.55	....	... ..	99.73
Romona Oolitic Stone Co.	Romona	Owen........	.....do	.....	.....	0.18	.....	....	.....	54.82	0.31	....	43.49	....	1.26	....	....	......	....	....	......	100.06
Peru Stone and Lime Co.	Peru........	Miami	J. N. Hurts, Indianapolis, Ind.	52.90	38.94	.....	4.05	1.20	1.25	.....	......	2.63	.....	....	....	....	....	......	....	....	......	100.97
S. Casparis	Kenneth....	Cass........	S. S. Gorby, State geologist.	93.48	.....	2.07	1.83	....	.....	.....	1.16	1.57	.....	0.39	....	....	....	......	....	....	......	100

THE BEDFORD OÖLITIC LIMESTONE.

By C. E. SIEBENTHAL.

Occurrence.—The Bedford limestone occurs as a massive stratum, varying from a few feet to nearly 100 feet in thickness, intercalated near the middle of the Lower Carboniferous limestone of Indiana. Its labyrinthine outcrop has been traced in detail through an extent of over 60 miles through Owen, Monroe, and Lawrence counties. To the south of this area extensive deposits of good stone are known to occur in Washington, Harrison, and Crawford counties, and though the exact limits of these deposits remain to be traced the stone is undoubtedly continuous southward from Lawrence County to the Ohio River. The stratum is massive, often without an interruption from top to bottom, and the size of the blocks which may be quarried is limited only by the capacity of the quarry machinery and transportation facilities.

Physical character.—The Bedford limestone is essentially a freestone in that it works nearly equally well in all directions. This fact is due to its semiorganic, semiclastic nature. In places its true oölitic character shows its organic origin, while in others the oölites are entirely wanting and the local cross bedding and granular structure betray its clastic origin. The size of the grains varies in different parts of the oölitic area and in different horizons at any one locality. Scattered over the whole oölitic area are local developments of the limestone in which the granules are very small, with remarkable uniformity and homogeneity. This constitutes the so-called "No 1 stone," which just now has the call of the market. The coarser varieties, though quite as durable and easily worked, and as handsome when erected, are comparatively neglected.

Color.—The original color of the oölitic stone in all cases varied from a light to a rather deep blue. On the outcrops and along the vertical clay seams, where the stone has been exposed to the leaching action of terrestrial water impregnated with organic acids, the stone has been changed to a buff. The bluer the stone was originally the more pronounced the buff after leaching. The lighter varieties of the unbleached stone can scarcely be told from the bleached stone of the same variety. It is a peculiar fact that the freshly quarried blue stone does not bleach on exposure to the air, but turns a deeper blue—that is to say, the outer surface does, but beneath this thin coat the stone has a pronounced reddish cast as far down as it has been affected. It is for this reason that buildings built of the blue stone do not become buff in course of time, as would be expected.

Both the "buff" and the "blue" stone are marketed, though the mixed buff and blue is almost a dead loss. At present the demand is strongest for the former color. A few years ago the preference was for the blue stone, and in a few years is likely to be so again. While the buff stone is necessarily confined to that zone which has been subjected to the leaching action of terrestrial water and is thus limited in quantity, the blue stone, on the contrary, extends back as far as the ledge reaches, and the accessible amount is limited only by excessive stripping. It may be remarked in passing that heavy stripping, or rather rock stripping, has been found to be not so disadvantageous as was formerly supposed. The expense of stripping in all cases must be distributed between the channel cuts of salable stone below, and the more channel cuts of such stone the larger the profit on each. Rock stripping means that the expense is to be borne by the full thickness of the oölitic stratum. Furthermore, a rock stripping generally acts as a roof, keeping the oölitic stone below free from percolating waters and thus diminishing the loss from mixed stone and from clay seams.

It is to be presumed that the blue stone, not having been subject to leaching and weathering, is the stronger and more durable stone, but no tests have been made which bear on the question other than the tests of actual experience in buildings, and the facts in regard to such are not sufficient to warrant a conclusion.

Crushing strength.—Formerly great crushing strength was the first desideratum in a building stone, but in these days of steel skeleton construction a more moderate crushing strength is required and more stress is laid on pleasing color, ease of working, and homogeneity of texture. Many compression tests have been made upon the Bedford limestone, in both the green and seasoned states, and with sawed and tool-dressed specimens. The results vary widely, as might be expected. A series of tests recently made under uniform conditions gave an average of 7,000 pounds per square inch for 2-inch sawed cubes, with a maximum of 13,200 pounds. It is a well-known fact that the crushing strength increases with increase in the size of the specimen tested. The large masonary blocks are able to stand a much greater pressure per square inch than the 2-inch cubes used in making the tests. The result of the tests shows a very ample margin over what the stone is called upon to bear in the lower masonary courses of the tallest buildings.

Refractoriness.—A series of experiments on 1-inch cubes were made to determine the fire resisting qualities of the Bedford limestone. Heated to 1,000° F. and plunged in cold water, the cubes were not affected. Heated to 1,200° F. and plunged in cold water, the cube crumbled slightly along the lower edges. Heated to 1,500° F. and cooled in air, the cubes retained their forms intact but were calcined in a marked degree. This shows that the stone will withstand the effects of fire up to the point of calcination.

Chemical composition.—The Bedford limestone is a nearly absolutely pure limestone of remarkably uniform composition. Lime carbonate constitutes on the average 97 per cent of the whole, varying in different samples from 95 per cent to 98 per cent. It thus equals in point of purity the French Caen limestone, and surpasses the English Portland oölitic limestone, the former of which contains 97.60 per cent of lime carbonate and the latter 95.16 per cent. It is excelled in purity by the purest marbles only.

Durability.—Since no structure built of Bedford stone is known of greater age than 60 years, we must estimate its durability from the well-known durability of pure limestone and the ability of the Bedford stone to withstand sudden extremes of heat and cold as shown by the fire tests above.

The effects of weathering exhibited by buildings 60 years of age are inconsiderable.

THE QUARRY DISTRICTS.

The quarries of the oölitic belt naturally group themselves into the following districts: Romona, Owen County; Stinesville, Ellettsville, Bloomington, and Sanders, Monroe County; and Bluff Ridge, Dark Hollow, and Bedford, Lawrence County.

Romona district.—This, the most northerly of the quarry districts, is in Owen County at Romona Station, on the Indianapolis and Vincennes division of the Pittsburg, Cincinnati and Chicago Railroad.

First and last a number of quarries have been in operation here, though at present but 3 are equipped with machinery, and but 1 was in operation in 1897.

The equipment in this district is as follows: 10 channelers, 7 saw gangs, 3 planes, 1 lathe, and the necessary travelers, derricks, steam drills, etc.

Stinesville district.—The first quarries to be operated on a businesslike scale in the oölitic limestone belt were on Big Creek, 1 mile west of Stinesville. These were opened in 1854 by the firm of Biddle, Watts & Co., of Pittsburg, Pennsylvania A quarry is still in operation on the site of the old quarry. Ten quarries have been opened in this district, of which 7 are now equipped with machinery, though but 2 were in operation in 1897. The equipment of the district is 18 channelers, 21 saw gangs, 3 planers, 2 lathes, etc.

Ellettsville district.—This also was one of the early regions to be developed. In all, 9 quarries have been opened, of which 3 were still in operation in 1897. The equipment consists of 3 channelers and 16 saw gangs.

Bloomington district.—The quarries of the district are located in Hunter Valley, which lies 2 miles northeast of the city of Bloomington. The region has been only recently developed, the first quarry being opened in 1890. Nine quarries have been opened, of which 7 were still in operation in 1897. The equipment shows 28 channelers and 22 saw gangs.

Sanders district.—This district includes the quarries in the vicinity of Sanders station, on the Chicago, Indianapolis & Louisville Railway (Monon route), and has been developed since 1888. Eight quarries have been opened, in all of which, with one exception, the machinery is still in place, though but 4 were in operation in 1897. The equipment is 20 channelers, 10 saw gangs, etc.

Buff Ridge district.—This district lies about the village of Oolitic, Lawrence County. It is the most productive district of the oölitic area, producing in 1897 nearly one-half of the entire output of Bedford oölitic stone. Out of 10 quarries which have been opened, 7 are still in operation, though but 5 were active in 1897. The equipment is as follows: 50 channelers, 20 saw gangs, 6 planes, and 1 lathe.

Dark Hollow district.—This was one of the first districts to be opened up in a large way and has contributed very largely to establish the reputation of the Bedford stone. In all, 6 quarries have been opened, of which 3 were in operation in 1897. The equipment consists of 15 channelers, 6 saw gangs, drills, etc.

Bedford and vicinity.—The remainder of the quarries in Lawrence County are grouped more or less closely about Bedford. Sixteen quarries have been opened in this region, of which 10 are still in operation, though but 3 were active in 1897. The equipment consists of 20 channelers, 44 saw gangs, 7 planers, and 7 lathes.

PRICES.

At the beginning of the industrial depression in 1893 the price of Bedford stone was 20 cents per cubic foot in scabbled blocks, free on board cars at the quarry. This price was maintained by general agreement until 1895, since which time prices have fallen nearly one-half. The price of mill blocks to-day runs from 10 cents to 20 cents per cubic foot, with the larger amount of sales much nearer the former figure than the latter. The price for the season just past seems to have recovered to a certain extent, as an inspection of the figures below will show that, while the production has fallen off slightly from 1896, the value of the same shows a gain on that of the former year. A noticeable feature of the year just past has been the remodeling and enlarging of stone sawmills and the erection of new ones. Almost one-half of the product for the year was worked up in home mills. This may account in part for the apparent advance in price noted above.

Production and value of Bedford oölitic limestone from 1894 to 1897, inclusive.

	Quantity.	Value.
1894.	*Cubic feet.*	
Monroe and Owen counties	2,176,246	$576,962
Lawrence County	2,404,172	577,284
Total	4,580,418	1,154,246
1895.		
Monroe and Owen counties	2,337,716	751,792
Lawrence County	3,030,591	771,468
Total	5,368,307	1,523,260

Production and value of Bedford oölitic limestone from 1894 to 1897, inclusive—Cont'd.

	Quantity.	Value.
1896.	*Cubic feet.*	
Monroe and Owen counties	2,016,926	$483,749
Lawrence County	3,438,656	725,883
Total	5,455,582	1,209,632
1897.		
Monroe and Owen counties	1,792,586	502,748
Lawrence County	3,590,303	841,410
Total	5,382,889	1,344,158

IOWA.

The value of the limestone output in 1896 was $410,037; in 1897 the corresponding figure was $480,572. The quarries of Iowa are in general small, but the aggregate makes an industry of considerable magnitude.

KANSAS.

Better conditions have prevailed in the stone business of this State in 1897, as the value of the output increased from $158,112 in 1896 to $208,889 in 1897. Most of the producers speak in much more cheerful vein than for some years past.

KENTUCKY.

Business was not so good in 1897, for which year the output was valued at $40,815, considerably less than for 1896. However, during the latter part of the past year indications were decidedly better.

MAINE.

A few years ago, and notably in 1892, the production of limestone at Rockland and vicinity was an industry of much greater magnitude than at present. The decline has been simply on account of hard times, and judging from gains made during the past year the old status will be regained before long. The output for the State in 1896 was valued at $608,077, and for 1897 at $742,877. Practically all of the value represents the lime made at and near Rockland, which has made a national reputation for the quality and abundance of pure limestone there found.

The following analysis of limestone quarried by Mr. George W. Bachelder at his quarries at Union, Maine, was made by Mr. F. C. Robinson, of Brunswick, Maine:

Analysis of limestone from Union, Maine.

	Per cent.
Calcium carbonate, $CaCO_3$	95.20
Magnesium carbonate, $MgCO_3$	1.00
Silica, SiO_2	1.00
Water	2.70
Iron	Trace.
Total	99.90

The following analysis of limestone quarried by the McLoon and Stover Lime Company at their quarries at Warren, Maine, was made by Mr. S. P. Sharples, State Assayer, Boston, Massachusetts:

Analysis of limestone from Warren, Maine.

	Per cent.
Moisture	0.40
Silica, SiO_2	0.95
Magnesium carbonate, $MgCO_3$	45.13
Calcium carbonate, $CaCO_3$	53.52
Total	100.00

MARYLAND.

In Maryland, as in a few other States, the limestone industry seems to be lagging behind somewhat in the return to prosperity, as the value of the product of 1896 exceeds that of 1897; but conditions in the early part of 1898 were undoubtedly better, judging from the statements made by some of the leading producers. A large amount of oyster-shell lime is made in Maryland, and this competes with the limestone quarrying.

The following analysis of the limestone quarried by Mr. George M. Busbey at his quarry at Cavetown, Maryland, was made by Messrs. Lehman and Glaser, of Baltimore, Maryland:

Analysis of limestone from Cavetown, Maryland.

	Per cent.
Silica, SiO_2	0.47
Lime, CaO	55.51
Loss on ignition	44.02
Total	100.00

MASSACHUSETTS.

The value of the product in 1896 was $118,622; in 1897, $126,508. A slight gain is evident. The most abundant stone in Massachusetts is granite, and limestone quarrying has never been prominent.

The following analysis of lime made from limestone quarried by Messrs. Hutchinson Brothers, at their quarry at New Lenox, Massachusetts, was made by Mr. W. M. Habirshaw, chemist, New York State Agricultural Society:

Analysis of limestone from New Lenox, Massachusetts.

	Per cent.
Lime, CaO	95.66
Magnesia, MgO	.76
Oxide of iron and aluminum	.17
Silica, SiO_2	1.14
Loss on ignition	3.00
Total	100.73

MICHIGAN.

The value of the output in 1896 was $109,427; in 1897, $215,177, or nearly twice the figure for the former year. Business was in every way better than in 1896. Most of the product is burned into lime.

MINNESOTA.

There was an increase from $228,992 in 1896 to $236,397 in 1897, a difference not large enough, however, to have much significance.

MISSOURI.

The limestone industry of Missouri is one of considerable importance. While the value of the output is still considerably below that of 1890, it is an increase over the figure for 1896, for which year the output was valued at $802,968; while in 1897 the valuation was $1,018,202. The product is about equally divided between building and burning into lime.

The following is a table of analyses of various Missouri limestones:

Analyses of limestone quarried in Missouri.

Name of firm quarrying stone.	Location of quarry. Town.	Location of quarry. County.	Name and address of analyst.	Substances determined. Calcium carbonate, $CaCO_3$.	Substances determined. Magnesium carbonate, $MgCO_3$.
				P. ct.	*P. ct.*
Marble Head Lime Co	Springfield	Greene	R. Chauvenet & Bro., St. Louis, Mo.	99.46	......
Hannibal Lime Co	Hannibal	Marion	do	98.80	......
Star Lime Co	do	Ralls	do	99.64	0.21
Glencoe Lime and Cement Co	Glencoe	St. Louis	do	98.36	......
Ashgrove White Lime Association.	Ashgrove	Greene	Chas. W. Eoff	99.82	......

Name of firm quarrying stone.	Substances determined. Oxides of iron and aluminum.	Iron oxide.	Aluminum oxide, Al_2O_3.	Silica, SiO_2.	Magnesium oxide, MgO.	Siliceous matter insoluble in acids.	Manganese oxide.	Phosphorus anhydride, P_2O_5.	Sulphuric anhydride, SO_3.	Total.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Marble Head Lime Co	......	0.21	......	0.33	......	......	......	......	......	100.00
Hannibal Lime Co	0.40	......	......	0.08	0.02	......	......	......	......	99.30
Star Lime Co	......	......	......	......	......	0.15	......	......	......	100.00
Glencoe Lime and Cement Co.	0.68	......	......	......	0.26	0.70	......	......	......	100.00
Ashgrove White Lime Association.	......	0.01	0.05	0.12	Trace.	......	Trace.	None.	Trace	100.00

MONTANA.

Production fell off from a valuation of $83,927 in 1896 to $37,300 in 1897. Prosperity has not yet made its appearance in this State, judging from the expressions of producers and the fact that nearly all report a diminished output.

NEBRASKA.

Limestone quarrying has never amounted to much in this State, but a large advance was made in 1897, when the product was valued at $42,359, about four times the figure for 1896.

NEW JERSEY.

In 1896 a valuation of $134,213, and in 1897 that of $141,646, show that better conditions have prevailed during the past year.

The following analysis of limestone quarried by the estate of E. Weise, at Vernon, New Jersey, was made by Mr. H. B. Weaver, chemist:

Analysis of limestone from Vernon, New Jersey.

	Per cent.
Calcium carbonate, $CaCO_3$	52.450
Magnesium carbonate, $MgCO_3$	43.250
Iron oxide	1.340
Alumina, Al_2O_3	.545
Phosphorus, P	.035
Silica, SiO_2	2.280
Total	99.900

NEW YORK.

This State produces in greater or less quantity every kind of stone known to the trade. Its limestone output increased from a value of $1,591,966 in 1896 to $1,697,780 in 1897. About two-thirds of the product is used for building and road making, while the remainder is nearly all burnt into lime.

The following is a table of analyses of New York limestones:

Analyses of limestone quarried in New York.

Name of firm quarrying stone.	Location.		Name and address of analyst.	Substances determined.															
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Siliceous matter insoluble in acids.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Carbon dioxide, CO_2.	Aluminum oxide, Al_2O_3.	Ferric oxide, Fe_2O_3.	Sulphur, S.	Phosphoric anhydride, P_2O_5.	Phosphorus, P.	Sulphuric anhydride, SO_3.	Undetermined matter and loss.	Silica, SiO_2.	Total.
				P.c.	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*	*P.c.*
D. C. Hewitt (upper stratum).	Amsterdam.	Montgomery	J. M. Sherrerd, chemist, Troy Steel and Iron Co.			3.00		52.78	None.								a42.97	1.25	100.00
D. C. Hewitt (intermediate stratum).	.....do	.....do	.....do			1.08		52.46	None.								a42.64	3.82	100.00
D. C. Hewitt (lower stratum).	.....do	.....do	.....do			2.76		52.12	None.								a39.44	5.68	100.00
D. R. & H. Fogelsonger.	Williamsville.	Erie	Hugo Carlson, chemist, Johnson County, Johnstown, Pa.	96.54	1.00	0.64							0.10		0.01			1.17	99.46
Howes Cave Association.	Howes Cave	Schoharie	Prof. Chas. A. Chaeffer, president Iowa State University.	97.24	1.39	0.73								None.		Trace.		1.27	100.63
Ossining Lime Co.	Ossining	Westchester	Ledoux Chemical Laboratory.			0.23	0.20	30.04	22.28	47.14									99.89
ANALYSES OF LIME MADE FROM LIMESTONE QUARRIED IN NEW YORK.																			
Robinson and Ferris.	Mechanicsville.	Washington	M. L. Griffin, Mechanicsville, N. Y.					97.64	0.80		1.04	0.25						0.23	99.66
E. B. Alvord & Co.	Jamesville.	Onondaga	F. E. Englehardt, Ph. D., Syracuse, N. Y.			2.03	1.88	91.93	8.06							0.73			99.63
Chazy Marble Lime Co	Chazy	Clinton	Enrique Touceda, Troy, N. Y.					97.08	1.40		0.14	0.12						0.79	99.53

a Chiefly carbon dioxide, CO_2.

OHIO.

The stone output of Ohio is divided between sandstone and limestone, both of which are quarried in large amounts. The value of the limestone product in 1896 was $1,399,412; in 1897, $1,486,550. The product is used for lime burning to the extent of nearly two-thirds, while something like one-third is divided between building, road making, and blast-furnace flux.

The following is a table of analyses of Ohio limestones:

Analyses of limestone quarried in Ohio.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.							Total.
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Siliceous matter insoluble in acids.	Phosphoric anhydride, P_2O_5.	Phosphorus, P.	Silica, SiO_2.	
				Per cent.	*Per cent.*	*Per ct.*	*Per cent.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
Snowflake Lime Co	Bowling Green.	Wood	Edward Orton, State Geologist.	53.88	44.91	0.40	0.30				99.49
M. Daum & Son	Carey	Wyandot	do	56.40	41.99	0.31	0.48				99.18
T. J. Price & Co	Columbus	Franklin	do	94.80	1.21	0.80	3.20				100.01
D. P. Lloyd & Co	Fostoria	Wood	do	52.00	45.26	2.70	Trace.				99.96
N. E. Gregg & Co	Genoa	Ottawa	do	54.30	45.14	0.16	0.23				99.83
Casparis Stone Co	Cold Springs	Clark	Ellis Lovejoy, Columbus, Ohio.	54.05	44.94	0.23	0.49				99.71
Casparis Stone Co	Columbus	Franklin	Cleveland Rolling Mills chemist.	93.21	4.70	1.74					99.65
Norris & Christian Lime and Stone Co.	Marion	Marion	do	86.22	9.27	2.30	2.86		0.11		100.76
N. B. Eddy	Luckey	Wood	G. A. Kirchmaier, Toledo, Ohio.	54.10	44.90	0.36				0.45	99.81
Duncan & Bussard	Williston	Ottawa	do	53.90	44.82	0.21		0.001		0.21	99.141
Ohlemacher Lime Co	Sandusky	Erie	Edward Orton	89.08	8.34	0.35	1.51				99.28
J. Kingham	Rockyridge	Ottawa	do	54.10	44.27	0.29	0.87				99.53
Sugar Ridge Lime and Stone Co.	Sugarridge	Wood	do	55.23	43.12	0.69	0.84				99.88

PENNSYLVANIA.

Numerous comparatively small producers of limestone in this State aggregate annually a large output. This, in 1896, was valued at $2,104,774, and in 1897 at $2,327,870. A little less than half of the product was burned into lime, which is extensively used as a fertilizer, while the remainder was divided between blast-furnace flux, building, and road making. The amount devoted to blast-furnace flux increased quite decidedly in 1897.

The following is a table of analyses of Pennsylvania limestones:

Analyses of limestone quarried in Pennsylvania.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminium.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Ferric oxide, Fe_2O_3.	Aluminium oxide, Al_2O_3.	Siliceous matter insoluble in acids.	Silica, SiO_2.	Loss on ignition.	Phosphoric anhydride, P_2O_5.	Potassium oxide, K_2O.	Phosphorus, P.	Sulphur, S.	Total.
	Town.	County.																
				P. ct.	*P. ct.*	*P. c.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. c.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. c.*	*P. c.*	*P. ct.*	*P. ct.*	*Per ct.*
Carbon Limestone Co	Youngstown	Lawrence	S. W. McKeown	96.43	0.40	1.60						1.50				0.02	0.08	100.03
Steary & Co	Wrightsville	York	A. S. McCreath, Harrisburg, Pa.	54.26	44.51	.66						.56						99.99
R. McCoy Lime Co	Bridgeport	Montgomery	Chas. I. Reader	55.70	41.97	.72						1.58						99.97
Chickies Iron Co	Chickies	Lancaster	Chickies Iron Co. chemist	51.00	48.49					0.31		.36						100.16
James Copeland	Downingtown.	Chester	Jas. H. Eastewick, Germantown, Pa.	54.15	45.20				0.37									99.72
Abraham K. Stauffer	Esterly	Berks	Chas. T. Davies	55.58	39.21	1.22					3.89							99.90
Wm. H. Gelbach	Fairfield	Adams	Franklin Menger, Ph. D	85.23	2.78	1.50						10.30	0.19					100.00
Geo. W. Musselman	do	do	do	86.91	3.11				.60			8.85		0.12	0.38			99.97
Geo. W. Bachman	Freemansburg.	Northampton.	Irwin A. Bachman, Ph. D., Allentown, Pa.	89.09	5.16				.32	1.61		2.18						98.36
J. King McLanahan, jr.	Frankstown	Blair	Chemist of Shoenberger Steel Co.			1.00	54.90	None.				1.06	43.80					100.76
Wm. B. Rambo (quarry No. 1).	Norristown	Montgomery	Booth, Garrett & Blair, Philadelphia, Pa.	53.49	45.76				.45		.20							99.90
Wm. B. Rambo (quarry No. 2).	do	do	do	54.04	45.51				.20		.25							100.00
Jas. B. Smith (No. 1)	Reedsville	Mifflin	R. Kent, Burnham, Pa	95.75	2.03	1.36						1.69				.002		100.832
Jas. B. Smith (No. 2)	do	do	do	96.24	2.86	.61						.33				.002		100.042
Jno. C. Fisher	Richland Station.	Lebanon	A. S. McCreath, Harrisburg, Pa.	99.02	.67	.19						.07				.003		99.953
Listie Mining Co	Listie	Somerset	Chemist of W. Dewees Wood Co., McKeesport, Pa.	92.12	2.35	2.00					3.53					.02		100.02
Winfield Mineral Co.	West Winfield.	Butler	Chemist of Pennsylvania Salt Mfg. Co., Natrona, Pa.	95.10	1.12	1.00					2.78							100.00

ANALYSES OF LIME MADE FROM LIMESTONE QUARRIED IN PENNSYLVANIA.

Name of firm quarrying stone.	Town.	County.	Name and address of analyst.	Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminium.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Ferric oxide, Fe_2O_3.	Aluminium oxide, Al_2O_3.	Siliceous matter insoluble in acids.	Silica, SiO_2.	Loss on ignition.	Phosphoric anhydride, P_2O_5.	Potassium oxide, K_2O.	Phosphorus, P.	Sulphur, S.	Total.
Jno. Yeager	Dalmatia	Northumberland.	Dr. Wm. Frear, State Chemist.			6.80	81.38	1.34			2.43		7.05	0.35	0.65			100.00
R. McCoy Lime Co	Bridgeport	Montgomery	Chas. I. Reader			1.35	58.33	37.37				2.95						100.00

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RHODE ISLAND.

Very little limestone is produced in this State. It is all used for burning into lime.

SOUTH CAROLINA.

Thirty thousand dollars' worth of lime was manufactured from limestone quarried in the State during 1897. This output is slightly greater than that of 1896.

SOUTH DAKOTA.

Only about $4,000 worth of stone, used mainly for building, was quarried in 1897.

TENNESSEE.

The limestone product in 1897 was valued at $113,774. This figure is somewhat less than the value for 1896. Most of this represents the value of lime made.

TEXAS.

Production of limestone and lime fell off somewhat in 1897, when the product was valued at $57,258. The product is about equally divided between lime and blast-furnace flux.

The following analysis of limestone quarried by Mr. D. R. Boone, at his quarry at Oglesby, Texas, was made by Prof. H. H. Harrington, of the Agricultural and Mechanical College and Experiment Station, of Texas:

Analysis of lime from Oglesby, Texas.

	Per cent.
Silicious matter	1.09
Organic matter	.52
Iron oxide	.35
Calcium oxide, CaO	54.02
Magnesium oxide, MgO	.12
Sulphur trioxide, SO_3	.17
Carbon dioxide, CO_2	43.96
Total	100.23

UTAH.

About $10,000 worth of lime and limestone for flux was yielded in 1897. The output has never been large.

VERMONT.

Production increased from $147,138 in 1896 to $165,657 in 1897. All of the product is burned into lime.

The following analysis was made by Mr. S. P. Sharples, State Assayer for Massachusetts, of limestone quarried by Mr. L. H. Felton at his quarry at High Gate Springs, Vermont:

Analysis of limestone from High Gate Springs, Vermont.

	Per cent.
Calcium oxide, CaO	55.83
Magnesium oxide, MgO	Trace.
Oxides of iron and aluminum	.10
Silica, SiO_2	.40
Carbon dioxide, CO_2	43.65
Total	99.98

The following analysis was made by Prof. F. C. Robinson, of Bowdoin College, Brunswick, Maine, of lime made from limestone quarried by Mr. W. B. Fonda at his quarry at St. Albans, Vermont:

Analysis of lime from St. Albans, Vermont.

	Per cent.
Calcium oxide, CaO	99.23
Insoluble matter	.14
Alumina, Al_2O_3	Trace.
Iron	Trace.
Magnesium oxide, MgO	.60
Total	99.97

The following analysis was also made by Prof. F. C. Robinson of lime quarried and burned by Mr. John P. Rich at his quarry at Swanton, Vermont:

Analysis of lime from Swanton, Vermont.

	Per cent.
Calcium oxide, CaO	99.29
Magnesium oxide, MgO	.46
Ferrous oxide, FeO	.12
Silica, SiO_2	.10
Aluminum	Trace.
Manganese	Trace.
Total	99.97

VIRGINIA.

The value of the output in 1896 was $182,640; in 1897, $192,972. Most of the product is burned into lime.

The following analysis was made by Dr. Henry Froehling, Richmond, Virginia, of limestone quarried by the Moore Lime Company at their quarry at Eagle Rock, Virginia:

Analysis of limestone from Eagle Rock, Virginia.

	Per cent.
Calcium carbonate, $CaCO_3$	98.71
Magnesium carbonate, $MgCO_3$	.65
Oxides of iron and aluminum	.31
Silica, SiO_2	.25
Total	99.92

WASHINGTON.

Production increased from $83,742 in 1896 to $126,877 in 1897. Practically all of this value represents lime made.

WEST VIRGINIA.

Production in 1896 was valued at $59,113; the figure for 1897 was $61,546.

The following analysis was made by Mr. J. Blodget Britton, of Philadelphia, Pennsylvania, of limestone quarried by Mr. D. Y. Huddleston at his quarry at Snow Flake, Greenbrier County, West Virginia:

Analysis of limestone from Snow Flake, West Virginia.

	Per cent.
Calcium carbonate, $CaCO_3$	96.46
Magnesium carbonate, $MgCO_3$	1.11
Organic matter, loss on ignition	Trace.
Insoluble siliceous matter	.97
Sulphur	None.
Aluminum oxide, Al_2O_3	1.46
Phosphorus	None.
Total	100.00

WISCONSIN.

The limestone industry of this State is an important one and likely to become still more so as Western population increases. Most of the limestone quarried is converted into lime, which bears an excellent reputation to a greater than merely local extent.

The following analysis was made by Mr. George N. Prentiss, Milwaukee, Wisconsin, of limestone quarried by Messrs. Blair and Larson at their quarries at Lannon, Wisconsin:

Analysis of limestone from Lannon, Wisconsin.

	Per cent.
Calcium carbonate, $CaCO_3$	52.29
Magnesium carbonate, $MgCO_3$	42.27
Oxides of iron and aluminum	1.68
Silica, SiO_2	3.96
Total	100.20

The following analysis was made by Mr. Gustave Bode, Milwaukee, Wisconsin, of limestone quarried by the Ormsby Lime Company at their quarry at Brillion, Wisconsin:

Analysis of limestone from Brillion, Wisconsin.

	Per cent.
Calcium carbonate, $CaCO_3$	55.09
Magnesium carbonate, $MgCO_3$	43.96
Silica, SiO_2	.59
Aluminum oxide, Al_2O_3	.36
Total	100.00

SOAPSTONE.

By Edward W. Parker.

OCCURRENCE.

Soapstone, or talc, is found in nearly every State along the Atlantic slope, the principal deposits being in New York and North Carolina, though it is also quarried in New Hampshire, Vermont, Massachusetts, New Jersey, Pennsylvania, Maryland, Virginia, and Georgia. It has also been reported in some of the Western States, particularly in California, Arizona, South Dakota, Arkansas, and Texas. Prior to 1896 all of the commercial product in the United States was reported from States east of the Mississippi River. In 1896, however, 150 tons of what may be classed with the soapstone product was quarried on Santa Catalina Island, a part of Los Angeles County, California. This material is included in the soapstone product for want of better classification. It is in reality a variety of verd antique, which, while an "impure" quality of serpentine, is more highly prized than the pure. The California product possesses some peculiar and interesting characteristics. It is sufficiently hard to take a high polish, and can be turned on a lathe into cups and other articles, the sides being worked down until they are as thin as rather delicate porcelain. The product from this quarry in 1897 was about 20 per cent less than in 1896, but the difference was made up by an output of 30 tons of soapstone quarried in Shasta County, and which was ground for use in the manufacture of paper pulp.

The soapstone deposits of the Eastern States show widely varying qualities. In some places, notably at Gouverneur, Saint Lawrence County, New York, it occurs in a foliated or fibrous form, which makes it valuable as a filler or makeweight in the manufacture of medium grades of paper. This variety is known as fibrous talc, and is treated separately in these reports. The soapstone of Maryland, Pennsylvania, and New Jersey is also extensively used in paper manufacture. The entire product is ground. New Hampshire, Virginia, and North Carolina furnish soapstone suitable for sawing and manufacture into sinks, washtubs, griddles, slate pencils, etc. North Carolina also produces a very pure white soapstone or talc, which is used as the principal ingredient in complexion powders. Discoveries of soapstone deposits in Ohio (Seneca County) were reported in 1897, but careful investigation showed the reports to be without foundation.

PRODUCTION.

Excluding the output of fibrous talc, the production of soapstone in the United States has varied very little in the last six years. The largest output during this period was in 1892, when it amounted to 23,208 tons; the smallest product, of 21,070 tons, was in the following year. The average yearly production during the last six years was 22,171 short tons. In 1897 the product was 21,923 short tons—260 tons less than in 1896, and 248 tons less than the average. The value of the product has shown a much wider range than the amount, varying from $255,067 in 1893 to $423,449 in 1892. This has been due partly to fluctuations in price and partly to variations of the conditions in which it is first marketed. The values in these reports are taken for the material in its first marketable condition; hence a larger proportion of the product sold in the rough would materially lessen the aggregate value, and similarly a larger proportion of manufactured articles would increase the total value. Another factor that must be taken into consideration is the difference in the class of manufactured articles. The returns for 1897 show that there was an increase in the price per ton of rough soapstone from $8.63 in 1896 to nearly $12.30. The product sawed into slabs brought an average of $16.77 in 1896 and $19.63 in 1897. The value per ton of manufactured articles in 1896 was $22.92, while in 1897 it was $22.12. The value of ground soapstone declined from $9.70 in 1896 to $8.28.

The following table shows the amount and value of soapstone produced in the United States during the last five years and the conditions in which the product was sold:

Production of soapstone during the last five years.

Condition in which marketed.	1893.		1894.		1895.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
Rough	5,760	$51,600	5,620	$50,780	1,041	$8,886
Sawed into slabs	104	4,400	1,303	19,500	863	12,320
Manufactured articles (*a*)	7,070	123,600	6,425	244,000	*d* 10,789	170,791
Ground (*b*)	8,137	75,467	9,796	87,045	8,802	74,498
Total (*c*)	21,071	255,067	23,144	401,325	21,495	266,495

a Includes bath and laundry tubs; fire brick for stoves, heaters, etc.; hearthstones, mantels, sinks, griddles, slate pencils, and numerous other articles of everyday use.

b For foundry facings, paper making, lubricators, dressing skins and leather, etc.

c Exclusive of the amount used for pigment, which is included among mineral paints.

d Includes 1 ton of soapstone, reported as 325 gross of slate pencils.

Production of soapstone during the last five years—Continued.

Condition in which marketed.	1896.		1897.	
	Short tons.	Value.	Short tons.	Value.
Rough	1,550	$13,375	1,020	$12,535
Sawed into slabs	923	15,481	1,107	21,726
Manufactured articles (*a*)	*d* 10,133	232,261	12,095	267,583
Ground (*b*)	9,577	92,948	7,701	63,785
Total (*c*)	22,183	354,065	21,923	365,629

a Includes bath and laundry tubs; fire brick for stoves, heaters, etc.; hearthstones, mantels, sinks, griddles, slate pencils, and numerous other articles of everyday use.

b For foundry facings, paper making, lubricators, dressing skins and leather, etc.

c Exclusive of the amount used for pigment, which is included among mineral paints.

d Includes 50 tons manufactured into crayons and slate pencils.

In the following table are shown the amount and value of soapstone produced in the United States since 1880, exclusive of fibrous talc and soapstone ground for paint:

Annual product of soapstone since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	8,441	$66,665	1889	12,715	$231,708
1881	7,000	75,000	1890	13,670	252,309
1882	6,000	90,000	1891	16,514	243,981
1883	8,000	150,000	1892	23,208	423,449
1884	10,000	200,000	1893	21,070	255,067
1885	10,000	200,000	1894	23,144	401,325
1886	12,000	225,000	1895	21,495	266,495
1887	12,000	225,000	1896	22,183	354,065
1888	15,000	250,000	1897	21,923	365,629

FIBROUS TALC.

The only source of supply for this variety of soapstone continues at Gouverneur, Saint Lawrence County, New York. The production in 1897 was the largest ever obtained, but the value was less than in any year since 1891, with the exception of 1895, when the amount produced was about two-thirds of the product in 1897. The output in 1897 amounted to 57,009 short tons, valued at $396,936, against 46,089 short tons, worth $399,443, in 1896, indicating an increase of nearly 25 per cent in product, with a loss of 1 per cent in value. Had the same price obtained in 1897 as 1896 the value of the product last year would have exceeded $400,000. As it is, the value per ton has declined from $10.90 in 1894 to $9.45 in 1895, to $8.67 in 1896, and, finally, to $6.96 in 1897. Most of the product is ground before being marketed, but about 10,000 tons were sold in the rough state in 1897, bringing about $2.20 per ton, and this had the effect of lowering the general average price. The average price for ground talc in 1897 was $7.95, against $8.87 in 1896.

Fibrous talc is used principally as a filler or makeweight in the manufacture of the medium grades of paper. A small amount goes into the manufacture of paint and wall plasters.

The following table shows the amount and value of fibrous talc used for different purposes in 1895, 1896, and 1897:

Disposition of fibrous talc product in 1895, 1896, and 1897.

	1895.		1896.		1897.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
Sold crude	....	....	1,363	$2,726	9,800	$21,500
Paper filling	39,021	$369,007	44,726	396,717	47,209	375,436
Paint	48	552				
Wall plasters	171	1,338				
Total	39,240	370,897	46,089	399,443	57,009	396,936

IMPORTS.

The following table exhibits the imports of talc of all kinds since 1880. From 1880 to 1889 the imports were fairly regular. Since 1889 they have been very irregular. From 19,229 short tons, valued at $30,993 in 1889, they dropped to 1,044 tons, worth $1,560 in 1890, and 81 tons, worth $1,121 in 1891. They increased in 1892 to 531 tons, and again in 1893 to 1,360 tons, decreasing in 1894 to 622 tons. In 1895 they increased to 3,165 short tons, valued at $26,843, decreasing in 1896 to 1,966 tons, worth $18,693, and again in 1897 to 796 tons, worth $8,423:

Talc imported into the United States from 1880 to 1897, inclusive.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	....	$22,807	1889	19,229	$30,993
1881	....	7,331	1890	1,044	1,560
1882	....	25,641	1891	81	1,121
1883	....	14,607	1892	531	5,546
1884	....	41,165	1893	1,360	12,825
1885	....	24,356	1894	622	6,815
1886	....	24,514	1895	3,165	26,843
1887	(a)	49,250	1896	1,966	18,693
1888	24,165	22,446	1897	796	8,423

a Quantity not reported previous to 1888.

CANADIAN PRODUCTION.

In the following table is shown the output of soapstone in Canada for a period of eleven years. It will be observed that the values are usually much less than those given for the United States product, and the fluctuations in value are even more pronounced than in this country. In 1886 and 1887 the product was valued at $8 per ton. The output in both years was small. In 1888, with an increase of only 40 tons in product, the value fell to $2 per ton. In 1889 the output increased 55 tons and the price went up to $6 per ton. In 1890 the output increased to 917 tons, nearly five times the amount obtained in 1889, but the value increased only $69, the price per ton declining to $1.35. No output was reported in 1891. In 1892 the product was 50 per cent more than in 1890, the value increasing five times, or to $4.54 per ton. In 1893, with a decrease of nearly 50 per cent in the product, there was a decline to $2.68 per ton. The price declined again in 1894 to $1.78 per ton, and in 1895 advanced to $4.50 per ton, the output of 475 tons being valued at $2,138. In 1896 the production fell off 65 tons to 410 tons, while the price declined to $3 per ton.

These figures are obtained from the annual report of the geological survey of Canada:

Production of soapstone in Canada from 1886 to 1896.

Calendar year.	Tons.	Value.
1886	50	$400
1887	100	800
1888	140	280
1889	195	1,170
1890	917	1,239
1891	None.	None.
1892	1,374	6,240
1893	717	1,920
1894	916	1,640
1895	475	2,138
1896	410	1,230

CLAY STATISTICS.

By JEFFERSON MIDDLETON.

BRICK AND TILE.

INTRODUCTION.

The results of the fourth statistical canvass of the clay-working industries of the United States, by the Geological Survey, are shown in the following pages. At the opening of the building season the clay workers were encouraged to believe that the year would be one of unusual activity. The results of this canvass, however, show that their hopes were not well-founded, and 1897 closed as one of the poorest years known. This is evinced by the large number of firms which began operations in the spring, but shut down after a short season. The great coal strike of 1897 was also a factor in decreasing the output last year.

This opportunity is again taken to thank the clay workers of the country for their cooperation, especially the potters, who responded much more promptly and satisfactorily than in 1896.

In spite of the increased number of firms reporting as in operation, and the fact that the pottery product reported was far greater than in 1896, the grand total of the clay products declined nearly 3 per cent. This reduction, too, was not confined to any one variety of clay products, but every branch of the industry suffered except the pressed brick, the vitrified paving brick, and the fireproofing industry.

In 1897 an effort was made to collect the statistics of raw clay, the results of which are given in this report. Like all new statistical investigations, where the means at command for carrying on the work are limited, the results of the first canvass are not all that could be desired, but on the whole are as satisfactory as could be hoped for under the circumstances, and it is confidently expected that for 1898 the returns will be much more satisfactory.

PRODUCTION AND VALUE.

In the following table is given a résumé of the total value of the brick and tile and pottery products of the United States, in 1897, by States:

Value of clay products of the United States, in 1897.

State.	Total brick and tile.	Total pottery.	Grand total.
Alabama	$411, 028	$32, 350	$443, 378
Arizona	54, 143	....	54, 143
Arkansas	167, 439	16, 660	184, 099
California	659, 202	32, 703	691, 905
Colorado	389, 354	10, 000	399, 354
Connecticut and Rhode Island	1, 265, 170	71, 500	1, 336, 670
Delaware	68, 458	....	68, 458
District of Columbia	288, 981	3, 000	291, 981
Florida	89, 435	3, 500	92, 935
Georgia	948, 313	10, 700	959, 013
Idaho	15, 914	1, 800	17, 714
Illinois	4, 879, 674	518, 900	5, 398, 574
Indiana	2, 514, 584	297, 725	2, 812, 309
Iowa	1, 782, 231	39, 016	1, 821, 247
Kansas	252, 418	4, 100	256, 518
Kentucky	680, 938	125, 430	806, 368
Louisiana	370, 910	500	371, 410
Maine	800, 739	500	801, 239
Maryland	1, 070, 265	232, 017	1, 302, 282
Massachusetts	1, 950, 052	229, 344	2, 179, 396
Michigan	769, 570	22, 300	791, 870
Minnesota	567, 394	303, 875	871, 269
Mississippi	263, 100	12, 000	275, 100
Missouri	2, 344, 069	52, 459	2, 396, 528
Montana	231, 649	529	232, 178
Nebraska	351, 385	3, 980	355, 365
New Hampshire	439, 672	25, 000	464, 672
New Jersey	4, 195, 134	1, 127, 363	5, 322, 497
New York	5, 432, 239	183, 265	5, 615, 504
North Carolina	355, 324	13, 170	368, 494
North Dakota	62, 420	....	62, 420
Ohio	5, 897, 415	4, 720, 269	10, 617, 684
Oklahoma *a*	77, 622	....	77, 622
Oregon	115, 798	9, 005	124, 803
Pennsylvania	7, 171, 296	703, 399	7, 874, 695
South Carolina	290, 497	700	291, 197
South Dakota	21, 800	....	21, 800
Tennessee	571, 923	40, 370	612, 293

a Including New Mexico and Indian Territory.

Value of clay products of the United States, in 1897—Continued.

State.	Total brick and tile.	Total pottery.	Grand total.
Texas	1, 134, 829	62, 210	1, 197, 039
Utah	135, 781	1, 200	136, 981
Vermont	53, 485	....	53, 485
Virginia	804, 846	7, 200	812. 046
Washington	190, 720	2, 500	193, 220
West Virginia	595, 734	519, 520	1, 115, 254
Wisconsin	724, 282	10, 800	735, 082
Wyoming	3, 550	....	3, 550
United States	51, 460, 782	9, 450, 859	60, 911, 641
Per cent of total	84. 48	15. 52	100. 00

In the following table is given a statement of the value of the clay products of the United States from 1894 to 1897, by States:

Value of clay products of the United States, 1894 to 1897.

State.	1894.	1895.	1896.	1897.
Alabama	$266, 045	$301, 341	$372, 185	$443, 378
Arizona	18, 081	6, 855	55, 663	54, 143
Arkansas	212, 096	243, 959	216, 332	184, 099
California	841, 495	1, 421, 154	680, 207	691, 905
Colorado	478, 077	553, 383	328, 680	399, 354
Connecticut and Rhode Island	1, 011, 600	1, 128, 925	1, 448, 598	1, 336, 670
Delaware	46, 028	58, 615	61, 003	68, 458
District of Columbia	390, 672	373, 304	353, 565	291, 981
Florida	83, 587	114, 015	122, 144	92, 935
Georgia	699, 887	867, 355	905, 813	959, 013
Idaho	30, 268	18, 890	16, 000	17, 714
Illinois	8, 474, 360	7, 619, 884	5, 863, 247	5, 398, 574
Indiana	3, 135, 569	3, 117, 520	2, 674, 325	2, 812, 309
Iowa	2, 379, 506	1, 870, 292	1, 694, 402	1, 821, 247
Kansas	218, 575	246, 647	260, 087	256, 518
Kentucky	759, 675	839, 198	830, 809	806, 368
Louisiana	517, 262	415, 718	402, 412	371, 410
Maine	831, 782	737, 104	994, 731	801, 239
Maryland	1, 344, 865	1, 066, 987	1, 450, 055	1, 302, 282
Massachusetts	2, 339, 934	2, 221, 590	2, 262, 974	2, 179, 396
Michigan	2, 254, 329	1, 129, 195	1, 005, 405	791, 870
Minnesota	920, 510	1, 100, 135	596, 701	871, 269
Mississippi	142, 700	194, 750	224, 809	275, 100
Missouri	2, 615, 578	2, 799, 218	2, 680, 215	2, 396, 528

Value of clay products of the United States, 1894 to 1897—Continued.

State.	1894.	1895.	1896.	1897.
Montana	154, 429	204, 193	276, 311	232, 178
Nebraska	519, 784	214, 541	144, 373	355, 365
New Hampshire	503, 505	521, 567	598, 169	464, 672
New Jersey	3, 976, 555	4, 899, 120	4, 728, 003	5, 322, 497
New York	5, 164, 022	5, 889, 496	6, 414, 206	5, 615, 504
North Carolina	286, 680	400, 983	420, 899	368, 494
North Dakota	52, 400	48, 000	59, 625	62, 420
Ohio	10, 668, 498	10, 649, 382	9, 949, 571	10, 617, 684
Oklahoma *a*	56, 663	45, 307	38, 444	77, 622
Oregon	161, 988	138, 543	126, 345	124, 803
Pennsylvania	7, 428, 048	8, 807, 161	9, 063, 313	7, 874, 695
South Carolina	236, 697	276, 918	354, 275	291, 197
South Dakota	27, 002	10, 740	53, 004	21, 800
Tennessee	634, 344	522, 534	537, 325	612, 293
Texas	1, 028, 853	1, 030, 446	915, 753	1, 197, 039
Utah	176, 900	112, 586	137, 573	136, 981
Vermont	98, 052	132, 544	83, 274	53, 485
Virginia	937, 593	855, 768	879, 526	812, 046
Washington	515, 659	265, 445	161, 528	193, 220
West Virginia	673, 006	895, 777	902, 944	1, 115, 254
Wisconsin	1, 255, 376	944, 196	788, 995	735, 082
Wyoming	6, 850	8, 525	9, 659	3, 550
United States	64, 575, 385	65, 319, 806	62, 143, 507	60, 911, 641
Number firms reporting.	6, 264	6, 284	7, 298	7, 180

a Including New Mexico and Indian Territory.

As will be seen by these tables, the value of the clay products in 1897 was $60,911,641, as compared with $62,143,507 in 1896, a decline of $1,231,866, or 1.98 per cent. This decline is in spite of the increase in the value of the pottery product from $6,620,627 in 1896 to $9,450,859 in 1897, which of course indicates a continued decline in the value of the brick and tile product, as stated elsewhere.

The number of producers reporting decreased from 7,298 in 1896, to 7,180 in 1897. While this shows a slight decline in the total number of firms reporting, it is unquestionably true that the number heard from this year was larger than ever before, and the decline is accounted for by the fact that many of the firms taken to be idle in 1896 have since reported themselves entirely out of business and their names have not been included among the firms reporting.

The statistics of Maryland, as in 1896, were collected by the geological survey of that State, under the supervision of Prof. W. B. Clark, to whom thanks are here extended for the completeness of the figures furnished.

The following table gives a statement of the brick and tile products of the United States in 1897, showing in detail the value of each product by States:

Brick and tile products in the United States in 1897.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*			*Thousands.*		
Alabama	87	54,189	$289,253	$5.34	1,130	$13,175	$11.66	4,080	$41,000	$10.05
Arizona	26	8,510	49,393	5.80	205	4,250	20.73	....	....	....
Arkansas	63	23,455	133,555	5.69	1,013	8,656	8.54	2,142	19,778	9.23
California	92	88,890	509,955	5.74	843	31,950	37.90	30	450	15.00
Colorado	89	26,950	134,920	5.01	10,312	101,494	9.84	708	7,004	9.89
Connecticut and Rhode Island	60	200,130	1,017,250	5.08	3,200	89,400	27.94	4,015	50,270	12.52
Delaware	28	9,293	64,111	6.90	91	1,547	17.00	....	....	....
District of Columbia	17	36,950	209,110	5.66	695	8,075	11.62	65	520	8.00
Florida	35	16,390	87,335	5.33	120	1,250	10.42	....	....	....
Georgia	72	134,296	599,158	4.46	3,340	35,381	10.59	250	2,500	10.00
Idaho	20	2,192	14,824	6.76	100	1,000	10.00	....	....	....
Illinois	769	516,263	2,376,498	4.60	24,342	218,788	8.99	87,169	719,371	8.25
Indiana	793	224,042	1,012,547	4.52	8,394	94,935	11.31	27,239	266,638	9.78
Iowa	427	152,446	850,834	5.58	7,823	57,230	7.32	56,315	426,056	7.57
Kansas	66	18,543	103,081	5.56	1,791	14,887	8.31	17,463	127,600	7.31
Kentucky	114	71,642	355,313	4.96	2,349	19,390	8.25	1,500	13,500	9.00

Brick and tile products in the United States in 1897—Continued.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*			*Thousands.*		
Louisiana	65	64,807	$322,328	$4.97	4,241	$40,382	$9.52			
Maine	110	53,133	273,929	5.16	1,280	11,200	8.75	96	$1,301	$13.55
Maryland	122	116,841	702,957	6.02	5,316	92,344	17.37	150	1,200	8.00
Massachusetts	138	257,539	1,457,683	5.66	6,946	126,420	18.20			
Michigan	200	120,377	546,638	4.54	1,990	10,515	5.28	1,905	22,332	11.72
Minnesota	117	79,474	366,734	4.61	2,965	31,750	10.71	530	5,900	11.13
Mississippi	53	45,510	236,650	5.20	2,225	18,600	8.36	250	2,000	8.00
Missouri	280	221,102	999,352	4.52	21,537	224,016	10.40	19,620	182,625	9.31
Montana	29	20,658	122,494	5.93	1,110	15,468	13.94			
Nebraska	102	47,656	288,980	6.06	3,064	31,706	10.35	3,092	26,169	8.46
New Hampshire	53	82,221	417,272	5.08	100	1,500	15.00			
New Jersey	150	263,641	1,188,191	4.51	30,022	670,282	22.33	550	7,300	13.27
New York	311	828,868	3,657,750	4.41	18,046	263,166	14.58	28,145	309,564	11.00
North Carolina	148	61,451	303,305	4.94	1,219	8,588	7.05	10	70	7.00
North Dakota	9	10,218	62,420	6.11						
Ohio	1,035	290,522	1,358,333	4.68	36,229	357,613	9.87	85,665	597,905	6.98
Oklahoma[a]	35	11,966	72,318	6.04	72	1,096	15.22	130	1,272	9.78
Oregon	74	9,548	58,130	6.09	445	4,100	9.21	236	2,475	10.49

[a] Including the product from New Mexico and Indian Territory.

Brick and tile products in the United States in 1897—Continued.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*			*Thousands.*		
Pennsylvania	567	558, 084	$3, 178, 190	$5. 69	73, 627	$873, 057	$11. 86	41, 620	$336, 413	$8. 08
South Carolina	67	56, 760	258, 897	4. 56	1, 940	16, 150	8. 32	....	....	....
South Dakota	9	2, 450	17, 600	7. 18	20	200	10. 00	....	....	....
Tennessee	116	81, 241	406, 236	5. 00	5, 154	41, 351	8. 02	6, 045	37, 813	6. 25
Texas	184	107, 294	630, 009	5. 87	19, 177	147, 958	7. 72	3, 635	32, 475	8. 93
Utah	61	18, 614	97, 691	5. 25	1, 425	11, 065	7. 76	50	400	8. 00
Vermont	20	10, 790	53, 485	4. 96	....	....	....	....	....	....
Virginia	101	94, 782	574, 269	6. 06	11, 037	153, 422	13. 90	3, 000	30, 000	10. 00
Washington	42	14, 837	86, 607	5. 84	575	10, 063	17. 50	1, 875	20, 250	10. 80
West Virginia	55	30, 594	164, 177	5. 37	2, 033	19, 246	9. 47	38, 271	289, 886	7. 57
Wisconsin	164	134, 025	640, 592	4. 78	6, 243	48, 670	7. 80	....	....	....
Wyoming	5	490	3, 550	7. 24	....	....	....	....	....	....
United States	7, 180	5, 279, 674	26, 353, 904	5. 00	323, 786	3, 931, 336	12. 14	435, 851	3, 582, 037	8. 22
Per cent of total	....	....	43. 27	....	....	6. 46	....	....	5. 88	....

Brick and tile products in the United States in 1897—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value). [a]	Tile (not drain) (value). [b]	Miscellaneous (value). [c]	Total value.
Alabama	$500	$67,000	$100	....	....	....	....	....	$411,028
Arizona	....	....	....	....	$400	$100	....	....	54,143
Arkansas	240	3,000	2,000	....	70	....	$140	....	167,439
California	6,400	7,720	5,300	$90,430	300	2,000	....	$4,697	659,202
Colorado	....	38,465	1,750	40,000	....	20,000	1,680	44,041	389,354
Connecticut and Rhode Island	16,500	44,750	1,000	....	10,000	21,000	15,000	....	1,265,170
Delaware	....	....	2,800	....	....	....	....	....	68,458
District of Columbia	2,000	....	526	66,360	....	500	....	1,890	288,981
Florida	....	....	600	([d])	250	....	....	....	89,435
Georgia	1,000	12,904	5,000	[e] 242,450	34,600	15,000	320	....	948,313
Idaho	....	....	....	....	....	....	....	90	15,914
Illinois	61,067	106,377	531,993	165,071	418,500	177,782	97,000	7,227	4,879,674
Indiana	3,650	24,245	559,524	156,450	31,000	121,835	223,750	20,010	2,514,584
Iowa	2,800	8,700	372,070	44,300	500	7,540	6,700	5,501	1,782,231
Kansas	....	1,400	5,450	....	....	....	....	....	252,418
Kentucky	....	157,499	28,065	21,200	....	971	85,000	....	680,938

[a] Including terra-cotta lumber and hollow building tile or blocks.

[b] Including roofing tile, floor tile, encaustic and art tile.

[c] Including acid-proof brick, aquaria ornaments, art pottery, bath brick, book tile, building blocks, burnt clay ballast, cave blocks, chemical stoneware, chimney pipe and tops, clay conduits, clay furnaces, clay pipes, clay pots, coke oven tile, crucibles, cupola blocks, doorknobs, fence post stubs, ferring tile, fire-clay goods for glass manufacturers, including enamel smelters, fire mortar, flue lining, furnace brick, gas logs, gas retorts and settings, glass-melting pots, glass tank blocks, glazes, hip rolls and cresting, hollow brick, indestructible fence posts, invert blocks, lead pots, muffles, paving tile, plaques, retorts, saggers, sidewalk tile, slabs, slides, stone pumps, stoppers, supports, terra cotta statuary, grave and lot markers, toy marbles, wall coping, wash tubs, and well tubing.

[d] Included with Georgia.

[e] Including the product from Florida, South Carolina, and Tennessee.

Brick and tile products in the United States in 1897—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value). *a*	Tile (not drain) (value). *b*	Miscellaneous (value). *c*	Total value.
Louisiana	$500	$1,000	$200				$800	$5,700	$370,910
Maine		37,218	3,900	$473,191					800,739
Maryland	35,100	141,650	25,524		$6,000		18,470	47,020	1,070,265
Massachusetts	74,500	184,665	260		30,430	$70,000	500	5,594	1,950,052
Michigan	1,000	210	165,564	20,361		2,200	150	600	769,570
Minnesota	600	5,550	3,810	117,650	1,200	34,000	200		567,394
Mississippi	750	3,800	1,000					300	263,100
Missouri	86,723	157,502	25,800	458,368	11,000	14,404	8,320	175,959	2,344,069
Montana	145	79,486		14,056					231,649
Nebraska	3,560	650	320						351,385
New Hampshire	400	10,000				10,500			439,672
New Jersey	170,721	277,670	11,225	31,973	539,512	987,637	191,735	118,888	4,195,134
New York	2,680	339,740	25,385	116,000	420,601	56,410	150,360	90,583	5,432,239
North Carolina	1,250	2,950	3,148	34,005				2,008	355,324
North Dakota									62,420
Ohio	104,426	510,878	737,754	1,495,974	37,159	314,800	113,353	269,220	5,897,415
Oklahoma *d*		2,696						240	77,622

a Including terra-cotta lumber and hollow building tile or blocks.

b Including roofing tile, floor tile, encaustic and art tile.

c Including acid-proof brick, aquaria ornaments, art pottery, bath brick, book tile, building blocks, burnt clay ballast, cave blocks, chemical stoneware, chimney pipe and tops, clay conduits, clay furnaces, clay pipes, clay pots, coke oven tile, crucibles, cupola blocks, doorknobs, fence post stubs, ferring tile, fire-clay goods for glass manufacturers, including enamel smelters, fire mortar, flue lining, furnace brick, gas logs, gas retorts and settings, glass-melting pots, glass tank blocks, glazes, hip rolls and cresting, hollow brick, indestructible fence posts, invert blocks, lead pots, muffles, paving tile, plaques, retorts, saggers, sidewalk tile, slabs, slides, stone pumps, stoppers, supports, terra-cotta statuary, grave and lot markers, toy marbles, wall coping, wash tubs, and well tubing.

d Including the product from Indian Territory and New Mexico.

Brick and tile products in the United States in 1897—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value). *a*	Tile (not drain) (value). *b*	Miscellaneous (value). *c*	Total value.
Oregon	....	....	$22,993	$22,000	....	$5,600	$100	$400	$115,798
Pennsylvania	$61,830	$1,707,621	14,164	283,451	$157,000	92,880	110,620	356,070	7,171,296
South Carolina	....	12,750	1,500	(*d*)	200	....	1,000	....	290,497
South Dakota	....	4,000	....	....	....	....	....	....	21,800
Tennessee	4,026	35,497	27,950	(*d*)	....	19,050	....	....	571,923
Texas	1,060	23,235	4,180	48,115	100	2,050	....	245,647	1,134,829
Utah	....	26,625	....	....	....	....	....	....	135,781
Vermont	....	....	....	....	....	....	....	....	53,485
Virginia	29,000	2,755	1,800	....	1,100	....	500	12,000	804,846
Washington	....	21,800	2,500	46,500	....	3,000	....	....	190,720
West Virginia	9,500	28,696	400	81,629	1,500	....	700	....	595,734
Wisconsin	3,120	4,000	27,750	....	....	....	....	150	724,282
Wyoming	....	....	....	....	....	....	....	....	3,550
United States	685,048	4,094,704	2,623,305	4,069,534	1,701,422	1,979,259	1,026,398	1,413,835	51,460,782
Per cent of total	1.12	6.72	4.31	6.68	2.79	3.25	1.68	2.32	84.48

a Including terra-cotta lumber and hollow building tile or blocks.

b Including roofing tile, floor tile, encaustic and art tile.

c Including acid-proof brick, aquaria ornaments, art pottery, bath brick, book tile, building blocks, burnt clay ballast, cave blocks, chemical stoneware, chimney pipe and tops, clay conduits, clay furnaces, clay pipes, clay pots, coke oven tile, crucibles, cupola blocks, doorknobs, fence post stubs, ferring tile, fire-clay goods for glass manufacturers, including enamel smelters, fire mortar, flue lining, furnace brick, gas logs, gas retorts and settings, glass-smelting pots, glass tank block, glazes, hip rolls and cresting, hollow brick, indestructible fence posts, invert blocks, lead pots, muffles, paving tile plaques, retorts, saggers, sidewalk tile, slabs, slides, stone pumps, stoppers, supports, terra-cotta statuary, grave and lot markers, toy marbles, wall coping, wash tubs, and well tubing.

d Included with Georgia.

The following table gives the figures of the clay products of the United States in 1896, and is here reproduced for comparative purposes:

Clay products of the United States in 1896.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*			*Thousands.*		
Alabama	80	49,817	$263,708	$5.29	2,149	$22,300	$10.50	2,000	$22,252	$11.13
Arizona	19	9,060	51,593	5.69	140	3,250	23.21	....	....	....
Arkansas	71	26,472	161,872	6.11	2,455	25,260	10.29	400	4,000	10.00
California	91	74,240	391,567	5.27	1,039	34,424	33.13	120	1,400	11.66
Colorado	87	27,461	153,627	5.59	8,790	80,700	9.18	100	1,100	11.00
Connecticut	47	166,995	966,738	5.79	90	1,900	21.11	20	400	20.00
Delaware	26	8,091	57,433	7.09	....	....	....	....	....	....
District of Columbia	16	40,368	220,762	5.46	376	4,366	11.61	26	260	10.00
Florida	35	17,376	89,219	5.13	....	....	....	....	....	....
Georgia	88	132,469	615,771	4.64	2,390	21,678	9.07	390	5,660	14.51
Idaho	19	2,150	15,700	7.30	20	300	15.00	....	....	....
Illinois	836	586,506	2,831,752	4.83	21,995	196,658	8.94	60,955	486,519	7.98
Indiana	827	262,936	1,207,247	4.59	9,071	99,954	11.01	18,792	175,670	9.35
Iowa	519	172,195	1,003,624	5.83	6,088	47,386	7.78	14,385	112,985	7.85
Kansas	71	19,694	110,254	5.59	1,541	9,440	6.13	16,934	125,293	7.39
Kentucky	125	63,675	317,749	4.99	1,475	15,550	10.54	7,000	70,000	10.00
Louisiana	59	69,887	370,487	5.30	3,600	29,000	8.05	70	700	10.00

Clay products of the United States in 1896—Continued.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*			*Thousands.*		
Maine	117	68, 604	$375, 353	$5. 47	1, 695	$15, 650	$9. 23	20	$340	$17. 00
Maryland	137	144, 519	987, 706	6. 83	4, 572	97, 426	21. 35	186	2, 382	12. 80
Massachusetts	123	274, 956	1, 601, 537	5. 82	4, 240	109, 780	25. 89	....	....	....
Michigan	238	110, 523	590, 095	5. 34	2, 157	13, 827	6. 41	3, 650	40, 750	11. 16
Minnesota	146	87, 844	398, 872	4. 54	2, 839	21, 368	7. 52	3	75	25. 00
Mississippi	46	38, 867	208, 109	5. 36	1, 475	12, 400	8. 40	....	....	....
Missouri	290	263, 037	1, 317, 916	5. 00	31, 260	293, 193	9. 37	7, 500	61, 500	8. 20
Montana	28	29, 927	204, 366	6. 83	396	5, 208	13. 15	16	93	5. 81
Nebraska	110	20, 527	124, 746	6. 08	1, 020	9, 512	9. 32	125	800	6. 40
New Hampshire	64	109, 885	550, 789	5. 01	870	11, 680	13. 42	1, 000	8, 000	8. 00
New Jersey	140	237, 781	950, 113	3. 99	15, 655	340, 919	21. 77	2, 575	35, 600	13. 82
New York	295	931, 565	4, 141, 973	4. 45	18, 409	298, 515	16. 22	23, 723	259, 550	10. 94
North Carolina	129	67, 015	370, 129	5. 52	513	5, 060	9. 86	160	1, 900	11. 87
North Dakota	8	10, 100	59, 625	5. 90	....	....	....	....	....	....
Ohio	1, 021	313, 995	1, 516, 088	4. 83	29, 890	337, 567	11. 29	72, 254	619, 463	8. 57
Oklahoma *a*	25	5, 533	35, 882	6. 49	90	1, 060	11. 78	....	....	....
Oregon	66	8, 775	55, 719	6. 34	275	2, 062	7. 50	200	3, 000	15. 00
Pennsylvania	536	675, 444	4, 118, 206	6. 10	47, 213	662, 188	14. 03	47, 229	404, 182	8. 57

a Including the product from Indian Territory and New Mexico.

Clay products of the United States in 1896—Continued.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*			*Thousands.*		
Rhode Island	1	28,000	$175,000	$6.25	3,000	$45,000	$15.00	4,000	$48,000	$12.00
South Carolina	56	70,114	305,150	4.35	420	2,600	6.19	10	125	12.50
South Dakota	11	7,265	51,004	7.02	....	....	....	....	....	....
Tennessee	101	65,548	364,463	5.56	7,881	66,865	8.48	7,503	54,030	7.20
Texas	149	113,027	665,091	5.88	12,891	142,500	11.05	1,400	9,200	6.57
Utah	54	15,808	96,161	6.08	3,165	35,862	11.33	....	....	....
Vermont	18	15,760	78,920	5.00	75	1,046	13.95	....	....	....
Virginia	114	101,311	604,161	5.96	13,087	195,046	14.90	3,000	30,000	10.00
Washington	52	10,164	55,758	5.48	422	8,390	19.88	3,196	31,500	9.85
West Virginia	45	29,462	164,831	5.59	972	11,370	11.70	21,485	177,856	8.28
Wisconsin	157	116,001	662,617	5.71	5,404	48,671	9.00	....	....	....
Wyoming	5	520	4,560	8.76	....	....	....	....	....	....
United States	7,298	5,701,269	29,664,043	5.20	271,105	3,386,931	12.49	320,407	2,794,585	8.72
Per cent of total	....	....	47.74	....	....	5.45	....	....	4.50	....

Clay products of the United States in 1896—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fire-proofing (value). *a*	Tile, not drain (value). *b*	Miscellaneous (value). *c*	Total brick and tile (value).	Total pottery (value).	Grand total.
Alabama	$1,200	$56,300							$365,760	$6,425	$372,185
Arizona	20						$800		55,663		55,663
Arkansas		1,200	$1,500						193,832	22,500	216,332
California	6,691	11,875	4,528	$208,000	$2,000	$2,700			663,185	17,022	680,207
Colorado		46,323	100	40,000			4,330	$2,500	328,680		328,680
Connecticut		71,800	14,100	2,460	30,000	500	15,000		1,102,898	48,700	1,151,598
Delaware			3,570						61,003		61,003
Dist. Columbia	500		1,475	39,558		1,000	1,000	81,644	350,565	3,000	353,565
Florida			30,000	500	125				119,844	2,300	122,144
Georgia	1,000	25,297	8,740	*d*172,662	32,280	15,565			898,653	7,160	905,813
Idaho									16,000		16,000
Illinois	52,624	125,408	517,684	187,350	720,100	213,315	110,355		5,441,765	421,482	5,863,247
Indiana	36,050	28,350	475,919	125,839	65,150	136,461	175,390	19,950	2,545,980	128,345	2,674,325
Iowa		5,198	225,650	73,039	800	7,685	2,000	173,000	1,651,367	43,035	1,694,402
Kansas		2,300	4,400			900		250	252,837	7,250	260,087
Kentucky		168,210	24,750	55,000		7,800	76,000		735,059	95,750	830,809
Louisiana		25	1,600						401,812	600	402,412

a Including terra-cotta lumber and hollow building tile or blocks. *b* Including roofing tile, floor tile, encaustic and art tile.

c Including conduits for underground wire, flue lining, fire kindlers, stone pumps, fence posts, Cornwall stone, clay pipes (smoking), terra-cotta chimneys, clay furnaces, burnt-clay ballast, chimney tops, statuary, paper clay, glass-house pots, fire-clay shapes, glass-house furnace blocks, clay pots, gas retorts, specialties for glass melters, china casts, acid brick, doorknobs, vitrified wall coping, pots and furnace supplies, toy marbles, lot markers, ovalware roasters, burnt clay and clay posts.

d Including Tennessee's product.

Clay products of the United States in 1896—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fire-proofing (value). *a*	Tile, not drain (value). *b*	Miscellaneous. (value). *c*	Total brick and tile (value.)	Total pottery (value).	Grand total.
Maine	$2,450	$42,000	$4,738	$551,613	$1,337	$1,000	....	....	$994,481	$250	$994,731
Maryland	37,300	150,655	1,945	....	5,075	....	$27,003	$112,867	1,422,359	27,696	1,450,055
Massachusetts	88,000	131,950	....	....	52,164	73,000	200	....	2,056,631	206,343	2,262,974
Michigan	4,600	2,300	225,293	105,140	750	2,450	50	....	985,255	20,150	1,005,405
Minnesota	100	1,375	5,240	117,620	....	10,290	325	....	555,265	41,436	596,701
Mississippi	800	2,000	500	....	....	....	....	....	223,809	1,000	224,809
Missouri	136,964	328,148	23,383	171,652	11,000	44,956	14,400	226,200	2,629,312	50,933	2,680,245
Montana	2,636	54,520	1,000	4,330	187	3,913	58	....	276,311	....	276,311
Nebraska	3,065	3,000	250	....	....	500	2,500	....	144,373	....	144,378
New Hampshire	700	10,000	....	....	....	....	....	....	581,169	17,000	598,169
New Jersey	188,819	604,983	37,850	16,205	618,502	721,694	143,292	884	3,658,861	1,069,142	4,728,003
New York	17,854	345,485	292,954	85,289	484,113	72,410	99,060	5,270	6,102,473	311,733	6,414,206
North Carolina	....	3,945	1,910	23,000	....	....	....	....	405,944	14,955	420,899
North Dakota	....	....	....	....	....	....	....	....	59,625	....	59,625
Ohio	62,982	575,748	569,871	2,058,210	63,100	279,264	805,198	162,730	7,050,221	2,899,350	9,949,571
Oklahoma *d*	....	5,099	....	....	....	....	....	1,502	38,444	....	38,444
Oregon	175	200	14,239	40,000	....	2,000	150	1,000	118,545	7,800	126,345

a Including terra-cotta lumber and hollow building tile or blocks. *b* Including roofing tile, floor tile, encaustic and art tile.

c Including conduits for underground wire, flue lining, fire kindlers, stone pumps, fence posts, Cornwall stone, clay pipes (smoking), terra-cotta chimneys, clay furnaces, burnt-clay ballast, chimney tops, statuary, paper clay, glass-house pots, fire-clay shapes, glass-house furnace blocks, clay pots, gas retorts, specialties for glass melters, china casts, acid brick, doorknobs, vitrified wall coping, pots and furnace supplies, toy marbles, lot markers, ovalware roasters, burnt clay and clay posts.

d Including the product from Indian Territory and New Mexico.

Clay products of the United States in 1896—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fire-proofing (value). *a*	Tile, not drain, (value). *b*	Miscellaneous (value). *c*	Total brick and tile (value).	Total pottery (value).	Grand total.
Pennsylvania	$30,545	$2,083,414	$49,039	$323,239	$142,200	$104,401	$122,707	$405,591	$8,445,712	$617,601	$9,063,313
Rhode Island	10,000	3,000	....	....	....	....	16,000	....	297,000	....	297,000
South Carolina	....	22,400	700	22,000	....	....	....	200	353,175	1,100	354,275
South Dakota	....	2,000	....	....	....	....	....	....	53,004	....	53,004
Tennessee	685	4,372	8,575	(*d*)	....	....	674	....	499,664	37,661	537,325
Texas	3,150	8,315	2,040	21,626	....	....	1,135	4,615	857,672	58,081	915,753
Utah	500	5,050	....	....	....	....	....	....	137,573	....	137,573
Vermont	....	....	3,308	....	....	....	....	....	83,274	....	83,274
Virginia	24,283	2,678	2,918	....	....	....	....	10,000	869,086	10,440	879,526
Washington	1,500	8,300	3,700	47,000	1,100	3,100	....	....	160,348	1,180	161,528
West Virginia	32,237	1,500	22,972	77,171	....	....	....	4,300	492,237	410,707	902,944
Wisconsin	15,710	....	27,797	20,000	....	....	500	1,200	776,495	12,500	788,995
Wyoming	....	....	....	....	....	....	....	....	9,659	....	9,659
United States	763,140	4,944,723	2,614,238	4,588,503	2,229,983	1,704,904	1,618,127	1,213,703	55,522,880	6,620,627	62,143,507
Per cent of total	1.23	7.96	4.21	7.38	3.59	2.74	2.60	1.95	89.35	10.65	100.00

[a] Including terra-cotta lumber and hollow building tile or blocks.

[b] Including roofing tile, floor tile, encaustic and art tile.

[c] Including conduits for undergronud wire, flue lining, fire kindlers, stone pumps, fence posts, Cornwall stone, clay pipes (smoking), terra-cotta ahimneys, clay furnaces, burnt-clay ballast, chimney tops, statuary, paper clay, glass-house pots, fire-clay shapes, glass-house-furnace blocks, clay pots, gas retorts, specialties for glass melters, china casts, acid brick, doorknobs, vitrified wall coping, pots and furnace supplies, toy marbles, lot markers, ovalware roasters, burnt clay and clay posts.

[d] Included with Georgia.

As will be noted by these tables, the number of common brick made in 1897 was 5,279,674,000, valued at $26,353,904, or $5 per thousand, as compared with 5,701,269,000 in 1896, worth $29,664,043, or $5.20 per thousand. In 1896 this class of brick constituted 47.74 per cent of the total clay products of the country, while in 1897 it constituted 43.27 per cent of the grand total. As in 1896, New York was the largest producer of this variety of brick, 828,868,000 being made in that State in 1897 and 931,565,000 in 1896. Pennsylvania was second in both years, and Illinois third in both years. In 1897 there were made 323,786,000 pressed brick, including buff, gray, and other fancy-colored brick, valued at $3,931,336, or $12.14 per thousand, while in 1896 there were made 271,105,000, worth $3,386,931, or $12.49 per thousand. In 1896 5.45 per cent of the total product was pressed brick, while in 1897 it constituted 5.46 per cent of the total value. Pennsylvania, New Jersey, and Ohio were the largest producers, in point of value, of pressed brick in both 1896 and 1897, in the order stated.

The product of vitrified paving brick increased from 320,407,000 in 1896, worth $2,794,585, or $8.72 per thousand, to 435,851,000 in 1897, valued at $3,582,037, or $8.22 per thousand. It is interesting to note that only three items in this table show an increase in 1897 over 1896, and that the vitrified brick product showed the greatest increase. The great vitrified brick producing region of the Ohio-Missisippi valleys, comprising the States of Iowa, Illinois, Indiana, Ohio, and West Virginia, in 1896 produced $1,572,493 worth of this product, or 56.27 per cent of the total, while in 1897 it produced $2,299,856 worth, or 64.21 per cent. The percentage of the total product in 1896 was 4.50, and in 1897 it was 5.88. Illinois, Ohio, and Iowa were the largest producers of vitrified paving brick in 1897, in the order named, while Ohio, Illinois, and Pennsylvania were the greatest producers in 1896.

The fancy or ornamental brick product showed a decrease from $763,140 in 1896 to $685,048 in 1897, which was a decrease of $78,092, or 10.23 per cent. The percentage of the total product in 1896 was 1.23, while in 1897 it was but 1.12. New Jersey and Missouri contributed most largely to this total in 1896, and New Jersey and Ohio were the largest producers of fancy brick, with Missouri third in 1897.

The fire-brick product decreased from $4,944,723 in 1896 to $4,094,704 in 1897, a loss of $850,019, or 17.19 per cent. Pennsylvania continues to hold her rank as the largest producer of fire brick, and although her product was more than twice that of any other State, she declined from $2,083,414 in 1896 to $1,707,621 in 1897. New Jersey lost her rank as second in the value of this product, being reduced to fourth place, Ohio with a product of $510,878 and New York with a product of $339,746, being respectively second and third. The percentages of the total product were 7.96 in 1896 and 6.72 in 1897.

The drain-tile product increased very slightly from $2,614,238 in 1896 to $2,623,305 in 1897. The States of Iowa, Illinois, Indiana, Michigan, and Ohio produced in 1896 $2,074,417 worth of drain tile, or 77.05 per cent of the total; in 1897 these States produced $2,366,905 worth, or 90.23 per cent of the total. The percentage of the total product of this variety of ware in 1896 was 4.21; in 1897 it was 4.31.

The sewer-pipe product decreased from $4,588,503 in 1896, or 7.38 per cent of the total product, to $4,069,534 or 6.68 per cent of the total product in 1897. Ohio, Pennsylvania, Maine, and Missouri are the largest producers of this class of goods. The decrease in 1897 was $518,969, or 11.31 per cent. In 1896 its percentage of the total product was 7.38; in 1897 it was 6.68.

The value of the ornamental terra cotta produced in 1897 declined from $2,229,983 in 1896 to $1,701,422, a decrease of $528,561, or 23.70 per cent. Its percentage of the total value was 3.59 in 1896 and 2.79 in 1897. New Jersey, New York, and Illinois continue to be the largest producers of ornamental terra cotta.

Fireproofing continued to increase. In 1897 its value was $1,979,259 as compared with $1,704,904 in 1896, or an increase of 16.09 per cent. This increase is only natural considering the popularity of this material in the construction of fireproof buildings. As in 1896, Illinois, Indiana, Massachusetts, New Jersey, Ohio, and Pennsylvania were the chief producing States. Its percentage of the total product increased from 2.74 in 1896 to 3.25 in 1897.

The tile product followed the general course of the clay industries in 1897 and declined. Its value in 1896 was $1,618,127, and in 1897 it was $1,026,398, a decrease of $591,729, or 36.57 per cent. In 1896 the percentage of the total product of this class of goods was 2.60; in 1897 it was 1.68.

The miscellaneous clay products, comprising a large variety of goods which can not properly be classified with any of the foregoing, but which are enumerated in a footnote to the table, increased from $1,213,703 in 1896 to $1,413,835 in 1897.

The total value of the brick and tile products, as will be seen by the table, was $51,460,782 in 1897 as compared with $55,522,880 in 1896, a decline of $4,069,098, or 7.32 per cent. In 1896 its percentage of the grand total was 89.35; in 1897 it was 84.48.

The following table gives a comparison of the clay industry in 1896 and 1897, showing the increase or decrease of the various items in 1897:

Value of clay products in the United States in 1896 and 1897, with increase or decrease.

	1896.	1897.	Increase in 1897.	Decrease in 1897.
Common brick	$29,664,043	$26,353,904	....	$3,310,139
Pressed brick	3,386,931	3,931,336	$544,405	....
Vitrified paving brick	2,794,585	3,582,037	787,452	....
Fancy or ornamental brick	763,140	685,048	....	78,092
Fire brick	4,944,723	4,094,704	....	850,019
Drain tile	2,614,238	2,623,305	9,067	....
Sewer pipe	4,588,503	4,069,534	....	518,969
Ornamental terra cotta	2,229,983	1,701,422	....	528,561
Fireproofing	1,704,904	1,979,259	274,355	....
Tile not drain	1,618,127	1,026,398	....	591,729
Miscellaneous	1,213,703	1,413,835	200,132	....
Total brick and tile	55,522,880	51,460,782	1,815,411	5,877,509
Decrease in brick and tile in 1897	....	....	....	4,062,098
Total pottery	6,620,627	9,450,859	2,830,232	....
Total	62,143,507	60,911,641	4,645,643	5,877,509
Net decrease in 1897	....	....	....	1,231,866

From this table it will be seen that only three of the brick and tile products showed any material increase in value in 1897, namely, pressed brick, vitrified paving brick, and fireproofing. One would naturally look for an increase in the production of the two latter varieties of goods. Vitrified paving brick, which were received with some hesitancy at first, have been in use long enough now to demonstrate their value, and a large increase in their use may be looked for. The use of fireproofing has also become essential in the construction of large buildings, and when building operations reach their normal proportions fireproofing will also show a great increase in product. The percentage of increase in the vitrified brick product was 28.18, while that of the fireproofing was 16.09.

The decrease in the product of common brick, $3,310,139, is the largest since the collection of the statistics of the clay products was begun by this office, and is itself more than twice the total decline in all the clay products.

As shown by this table, were it not for the increase in the pottery products the decrease in the total would have been over three times as great and the product would have fallen below the $60,000,000 mark.

The following tables show the rank of States, total value of products, and the percentage of the total product made by each State in 1897 and 1896.

Rank of States and output of clay products in 1897 and 1896.

1897.

Rank.	State.	Number of firms reporting.	Value.	Per cent of total product.
1	Ohio	1,035	$10,617,684	17.43
2	Pennsylvania	567	7,874,695	12.93
3	New York	311	5,615,504	9.22
4	Illinois	769	5,398,574	8.86
5	New Jersey	150	5,322,497	8.74
6	Indiana	793	2,812,309	4.62
7	Missouri	280	2,396,528	3.93
8	Massachusetts	138	2,179,396	3.58
9	Iowa	427	1,821,247	2.99
10	Connecticut and Rhode Island	60	1,336,670	2.19
11	Maryland	122	1,302,282	2.14
12	Texas	184	1,197,039	1.97
13	West Virginia	55	1,115,254	1.83
14	Georgia	72	959,013	1.57
15	Minnesota	117	871,269	1.43
16	Virginia	101	812,046	1.33
17	Kentucky	114	806,368	1.32
18	Maine	110	801,239	1.32
19	Michigan	200	791,870	1.30
20	Wisconsin	164	735,082	1.21
21	California	92	691,905	1.14
22	Tennessee	116	612,293	1.01
23	New Hampshire	53	464,672	.76
24	Alabama	87	443,378	.72
25	Colorado	89	399,354	.66
26	Louisiana	65	371,410	.61
27	North Carolina	148	368,494	.60
28	Nebraska	102	355,365	.58
29	District of Columbia	17	291,981	.48
30	South Carolina	67	291,197	.48
31	Mississippi	53	275,100	.45
32	Kansas	66	256,518	.42
33	Montana	29	232,178	.38
34	Washington	42	193,220	.32
35	Arkansas	63	184,099	.30
36	Utah	61	136,981	.23
37	Oregon	74	124,803	.21

Rank of States and output of clay products in 1897 and 1896—Continued.

1897—Continued.

Rank.	State.	Number of firms reporting.	Value.	Per cent of total product.
38	Florida	35	$92,935	.15
39	Oklahoma, New Mexico, and Indian Territory	35	77,622	.13
40	Delaware	28	68,458	.11
41	North Dakota	9	62,420	.10
42	Arizona	26	54,143	.09
43	Vermont	20	53,485	.08
44	South Dakota	9	21,800	.04
45	Idaho	20	17,714	.03
46	Wyoming	5	3,550	.01
	United States	7,180	60,911,641	100.00

1896.

Rank.	State.	Number of firms reporting.	Value.	Per cent of total product.
1	Ohio	1,021	$9,949,571	16.01
2	Pennsylvania	536	9,063,313	14.58
3	New York	295	6,414,206	10.32
4	Illinois	836	5,863,247	9.44
5	New Jersey	140	4,728,003	7.61
6	Missouri	290	2,680,245	4.31
7	Indiana	827	2,674,325	4.30
8	Massachusetts	123	2,262,974	3.64
9	Iowa	519	1,694,402	2.73
10	Maryland	137	1,450,055	2.33
11	Connecticut	47	1,151,598	1.85
12	Michigan	238	1,005,405	1.62
13	Maine	117	994,731	1.60
14	Texas	149	915,753	1.47
15	Georgia	88	905,813	1.46
16	West Virginia	45	902,944	1.45
17	Virginia	114	879,526	1.42
18	Kentucky	125	830,809	1.34
19	Wisconsin	157	788,995	1.27
20	California	91	680,207	1.09
21	New Hampshire	64	598,169	.96
22	Minnesota	146	596,701	.96
23	Tennessee	101	537,325	.86

Rank of States and output of clay products in 1897 and 1896—Continued.

1896—Continued.

Rank.	State.	Number of firms reporting.	Value.	Per cent of total product.
24	North Carolina	129	$420,899	.68
25	Louisiana	59	402,412	.65
26	Alabama	80	372,185	.60
27	South Carolina	56	354,275	.57
28	District of Columbia	16	353,565	.57
29	Colorado	87	328,680	.53
30	Rhode Island	1	297,000	.48
31	Montana	28	276,311	.44
32	Kansas	71	260,087	.42
33	Mississippi	46	224,809	.36
34	Arkansas	71	216,332	.35
35	Washington	52	161,528	.26
36	Nebraska	110	144,373	.23
37	Utah	54	137,573	.22
38	Oregon	66	126,345	.20
39	Florida	35	122,144	.20
40	Vermont	18	83,274	.13
41	Delaware	26	61,003	.10
42	North Dakota	8	59,625	.10
43	Arizona	19	55,663	.09
44	South Dakota	11	53,004	.09
45	Oklahoma [a]	25	38,444	.06
46	Idaho	19	16,000	.03
47	Wyoming	5	9,659	.02
	United States	7,298	62,143,507	100.00

[a] Including Indian Territory and New Mexico.

As in previous years, every State and Territory except Nevada and Alaska participated in this total. Ohio still holds the first position when value of product is considered, her product in 1897 being valued at $10,617,684 or 17.43 per cent of the total, which is $668,113 greater than her product in 1896, when her percentage of the total was 16.01. This increase is due entirely to the increased amount of pottery reported in 1897, the total value of the brick and tile reported in 1896 being $7,050,221 as compared with $5,897,415 in 1897, a loss of $1,152,806. The pottery product, however, increased from $2,899,350 in 1896 to $4,720,269, an increase of $1,820,919 in 1897. Pennsylvania is again second, with a product valued at $7,874,695, or 12.93 per cent of the total, as compared with $9,063,313, or 14.49 per cent of the total in

1896. New York, Illinois, and New Jersey retain their relative ranks of third, fourth, and fifth, respectively, in 1897, with products valued at $5,615,504, or 9.22 per cent of the total; $5,398,574, or 8.86 per cent of the total, and $5,322,497, or 8.74 per cent of the total, respectively.

Indiana, which was displaced from the sixth position in 1896 by Missouri, has regained that place and Missouri goes back to the seventh, which she has held every year since our statistics began, with the exception of 1896. Indiana's product was valued at $2,812,309 in 1897, or 4.62 per cent of the total product, while in 1896 her product was valued at $2,674,325, or 4.30 per cent of the total. Missouri's product in 1897 was valued at $2,396,528, or 3.93 per cent of the total; in 1896 her product was $2,680,245, or 4.31 per cent of the total product.

Massachusetts and Iowa retained the places they held in 1896, that is, eighth and ninth, respectively. Massachusetts' product was valued at $2,179,396 in 1897, or 3.58 per cent of the total; while in 1396 she produced $2,262,974 worth of clay goods, or 3.64 per cent of the total value.

The other changes worthy of note were: Maine, which held thirteenth place in 1896, dropped to eighteenth in 1897; Michigan dropped seven places, or from twelfth in 1896 to nineteenth in 1897, and Minnesota, which occupied twenty-second place in 1896, jumped to fifteenth in 1897, which is the rank this State held in 1894. Nebraska also advanced, being thirty-sixth in 1896 and twenty-eighth in 1897.

The first nine States, including the great clay-working region between the Ohio and Missouri rivers, together with Pennsylvania, New York, New Jersey, and Massachusetts, produced goods valued at $44,038,434, or 72.30 per cent of the total, in 1897; in 1896 they produced $45,330,286 worth, or 72.94 per cent of the total. In 1897 the States of Ohio, Illinois, Indiana, Missouri, and Iowa produced 37.83 per cent of the total; in 1896 they produced 36.79 per cent of the total.

In the following table is given a statement of the average price of the several varieties of brick for the whole country from 1894 to 1897, and is interesting as showing the gradual decrease in price for all of the varieties, except vitrified brick, which increased from $8.20 per thousand in 1895 to $8.72 in 1896, but declined again to $8.22 in 1897.

Value per thousand of common, pressed, and vitrified brick in 1894, 1895, 1896, and 1897.

Year.	Common.	Pressed.	Vitrified.
1894	$5.70	(*a*)	$8.12
1895	5.25	$12.97	8.20
1896	5.20	12.49	8.72
1897	5.00	12.14	8.22

a Common and pressed brick not separately classified in 1894.

The following table shows the average value per thousand of the several kinds of brick made in the United States in 1897, by States:

Average price of brick per thousand in 1897, by States.

COMMON BRICK.

State.	Price.	State.	Price.
Wyoming	$7.24	Mississipppi	$5.20
South Dakota	7.18	Maine	5.16
Delaware	6.90	Connecticut and Rhode Island	5.08
Idaho	6.76	New Hampshire	5.08
North Dakota	6.11	Colorado	5.01
Oregon	6.09	Tennessee	5.00
Nebraska	6.06	Louisiana	4.97
Virginia	6.06	Kentucky	4.96
Oklahoma *a*	6.04	Vermont	4.96
Maryland	6.02	North Carolina	4.94
Montana	5.93	Wisconsin	4.78
Texas	5.87	Ohio	4.68
Washington	5.84	Minnesota	4.61
Arizona	5.80	Illinois	4.60
California	5.74	South Carolina	4.56
Arkansas	5.69	Michigan	4.54
Pennsylvania	5.69	Indiana	4.52
District of Columbia	5.66	Missouri	4.52
Massachusetts	5.66	New Jersey	4.51
Iowa	5.58	Georgia	4.46
Kansas	5.56	New York	4.41
West Virginia	5.37	Average for United States	5.00
Alabama	5.34		
Florida	5.33		
Utah	5.25		

a Including the product of Indian Territory and New Mexico.

PRESSED BRICK.

State.	Price.	State.	Price.
California	$37.90	Maryland	$17.37
Connecticut and Rhode Island	27.94	Delaware	17.00
New Jersey	22.33	Oklahoma *a*	15.22
Arizona	20.73	New Hampshire	15.00
Massachusetts	18.20	New York	14.58
Washington	17.50	Montana	13.94
		Virginia	13.90

a Including the product of Indian Territory and New Mexico.

Average price of brick per thousand in 1897, by States—Continued.

PRESSED BRICK—continued.

State.	Price.	State.	Price.
Pennsylvania	$11.86	Maine	$8.75
Alabama	11.66	Arkansas	8.54
District of Columbia	11.62	Mississippi	8.36
Indiana	11.31	South Carolina	8.32
Minnesota	10.71	Kansas	8.31
Georgia	10.59	Kentucky	8.25
Florida	10.42	Tennessee	8.02
Missouri	10.40	Wisconsin	7.80
Nebraska	10.35	Utah	7.76
Idaho	10.00	Texas	7.72
South Dakota	10.00	Iowa	7.32
Ohio	9.87	North Carolina	7.05
Colorado	9.84	Michigan	5.28
Louisiana	9.52		
West Virginia	9.47	Average for United States	12.14
Oregon	9.21		
Illinois	8.99		

VITRIFIED PAVING BRICK.

State.	Price.	State.	Price.
California	$15.00	Kentucky	$9.00
Maine	13.55	Texas	8.93
New Jersey	13.27	Nebraska	8.46
Connecticut and Rhode Island	12.52	Illinois	8.25
Michigan	11.72	Pennsylvania	8.08
Minnesota	11.13	District of Columbia	8.00
New York	11.00	Maryland	8.00
Washington	10.80	Mississippi	8.00
Oregon	10.49	Utah	8.00
Alabama	10.05	Iowa	7.57
Georgia	10.00	West Virginia	7.57
Virginia	10.00	Kansas	7.31
Colorado	9.89	North Carolina	7.00
Indiana	9.78	Ohio	6.98
Oklahoma [a]	9.78	Tennessee	6.25
Missouri	9.31	Average for United States	8.22
Arkansas	9.23		

[a] Including the product of Indian Territory and New Mexico.

It will be noted from the foregoing tables that the price of common brick in 1897 ranged from $7.24 per thousand in Wyoming to $4.41 per thousand in New York. In 1896 Wyoming and New Jersey were the extremes, with average values of $8.76 and $3.99 per thousand, respectively, while the average of the whole country was $5.20. The value of the common brick produced in Tennessee in 1897 was identical with the average for the whole country, $5 per thousand.

The average price of pressed brick, including buff, gray, and other fancy-colored brick, varied in 1897 from $37.90 in California to $5.28 per thousand in Michigan, the average for the United States being $12.14 per thousand. In 1896 the extremes were California and Kansas, with an average price of $33.13 and $6.13 per thousand, the average for the whole country being $12.49. Pennsylvania's product in 1897 more nearly attained the general average than that of any other State.

The vitrified paving brick ranged in average value per thousand in 1897 from $15 in California to $6.25 in Tennessee. In 1896 the value varied from $15 per thousand in Oregon to $5.81 per thousand in Montana. The average for the whole country was $8.72 in 1896 and $8.22 per thousand in 1897. The Illinois product in 1897 was nearer the average value than that of any other State.

The following table shows the number of idle and number of active works reporting in 1896 and 1897, by States, together with the number reporting in 1895:

Number of active and idle clay-working plants in the United States in 1896 and 1897, and the number of firms reporting in 1895.

State.	1897.			1896.			Number of firms reporting in 1895.
	Active.	Idle.	Total.	Active.	Idle.	Total.	
Alabama	62	25	87	51	29	80	60
Arizona	21	5	26	16	3	19	9
Arkansas	46	17	63	48	23	71	54
California	58	34	92	60	31	91	94
Colorado	58	31	89	49	38	87	81
Connecticut and Rhode Island	48	12	60	42	6	48	45
Delaware	25	3	28	23	3	26	17
District of Columbia	14	3	17	12	4	16	16
Florida	19	16	35	19	16	35	28
Georgia	51	21	72	55	33	88	76
Idaho	11	9	20	10	9	19	14
Illinois	570	199	769	566	270	836	678
Indiana	580	213	793	556	271	827	659
Iowa	330	97	427	339	180	519	412

Number of active and idle clay-working plants in the United States in 1896 and 1897, and the number of firms reporting in 1895—Continued.

State.	1897.			1896.			Number of firms reporting in 1895.
	Active.	Idle.	Total.	Active.	Idle.	Total.	
Kansas	42	24	66	34	37	71	63
Kentucky	82	32	114	80	45	125	92
Louisiana	46	19	65	44	15	59	44
Maine	64	46	110	72	45	117	95
Maryland	98	24	122	96	41	137	65
Massachusetts	109	29	138	99	24	123	112
Michigan	149	51	200	156	82	238	200
Minnesota	87	30	117	88	58	146	126
Mississippi	37	16	53	37	9	46	38
Missouri	202	78	280	206	84	290	221
Montana	21	8	29	19	9	28	18
Nebraska	68	34	102	52	58	110	105
New Hampshire	48	5	53	52	12	64	54
New Jersey	115	35	150	103	37	140	130
New York	231	80	311	262	33	295	280
North Carolina	124	24	148	112	17	129	96
North Dakota	8	1	9	6	2	8	7
Ohio	842	193	1,035	814	207	1,021	980
Oklahoma *a*	28	7	35	11	14	25	21
Oregon	54	20	74	52	14	66	68
Pennsylvania	435	132	567	457	79	536	513
South Carolina	51	16	67	46	10	56	51
South Dakota	5	4	9	9	2	11	10
Tennessee	90	26	116	82	19	101	90
Texas	149	35	184	125	24	149	136
Utah	43	18	61	37	17	54	46
Vermont	13	7	20	12	6	18	20
Virginia	75	26	101	86	28	114	111
Washington	25	17	42	22	30	52	52
West Virginia	49	6	55	39	6	45	46
Wisconsin	127	37	164	130	27	157	146
Wyoming	3	2	5	4	1	5	5
Total	5,413	1,767	7,180	5,290	2,008	7,298	6,284

a Including Indian Territory and New Mexico.

In this table the number of works reporting as idle is necessarily more or less inaccurate, since a firm may have reported its works as not in operation, and they may be so tabulated, when in fact they should have been reported as abandoned and taken from the list of clay workers. This is demonstrated by the fact that while replies were received from more clay workers in 1897 than in any previous year, the table shows that returns were received from 118 less in 1897 than in 1896, this being accounted for by the fact that there have been included among those counted as not reporting many that have retired permanently from the clay-working industries.

The total number of firms reporting in 1897, as shown by this table, was 7,180, as compared with 7,298 in 1896. Nevertheless, the number of firms operating increased from 5,290 in 1896 to 5,413 in 1897, a gain of 123. The idle plants reported decreased from 2,008 in 1896 to 1,767 in 1897. As already explained, the number of idle plants decreased because works reported idle in 1896 have since been reported entirely out of the business.

An inspection of this table will show that the most important gains in the number of firms reporting a product were in the States of Alabama, Indiana, Massachusetts, Nebraska, New Jersey, North Carolina, Ohio, Texas, Virginia, and West Virginia, while the only States to show any considerable falling off were New York and Pennsylvania.

In the following table is shown the rank of the several States and Territories in the value of clay products from 1894 to 1897, inclusive:

Rank of clay-producing States, in value of production, in 1894, 1895, 1896, and 1897.

State.	1894.	1895.	1896.	1897.
Alabama	31	28	26	24
Arizona	46	47	43	42
Arkansas	34	33	34	35
California	16	10	20	21
Colorado	27	22	29	25
Connecticut (*a*)	20	20	11	10
Delaware	43	41	41	40
District of Columbia	28	27	28	29
Florida	40	39	39	38
Georgia	18	15	15	14
Idaho	44	44	46	45
Illinois	2	3	4	4
Indiana	6	6	7	6
Iowa	8	9	9	9
Kansas	33	32	32	32
Kentucky	19	19	18	17
Louisiana	24	25	25	26
Maine	17	21	13	18
Maryland	11	13	10	11
Massachusetts	9	8	8	8
Michigan	10	11	12	19

a Including Rhode Island in 1897.

Rank of clay-producing States, in value of production, etc.—Continued.

State.	1894.	1895.	1896.	1897.
Minnesota	15	12	22	15
Mississippi	38	36	33	31
Missouri	7	7	6	7
Montana	37	35	31	33
Nebraska	23	34	36	28
New Hampshire	26	23	21	23
New Jersey	5	5	5	5
New York	4	4	3	3
North Carolina	30	26	24	27
North Dakota	42	42	42	41
Ohio	1	1	1	1
Oklahoma (*b*)	41	43	45	39
Oregon	36	37	38	37
Pennsylvania	3	2	2	2
Rhode Island	29	29	30	(*c*)
South Carolina	32	30	27	30
South Dakota	45	45	44	44
Tennessee	22	24	23	22
Texas	13	14	14	12
Utah	35	40	37	36
Vermont	39	38	40	43
Virginia	14	18	17	16
Washington	25	31	35	34
West Virginia	21	17	16	13
Wisconsin	12	16	19	20
Wyoming	47	46	47	46

b Includes Indian Territory and New Mexico.
c Included with Connecticut.

This table is principally interesting as showing the slight changes in the relative rank of the clay-working States in the value of their products, the most notable changes being the gain of Nebraska and Minnesota of eight and seven places, respectively, and the loss of seven places by Michigan.

POTTERY.

INTRODUCTION.

The second statistical canvass of the pottery industry by the United States Geological Survey has been highly gratifying in its results, both in regard to the number of firms replying and in the increased product reported.

It is still to be regretted that all the operators at the great pottery center of New Jersey have not furnished returns. However, more firms reported than in 1896, and it is hoped that under the new tariff law the industry will be stimulated and that for 1898 more complete returns will be obtained. On the other hand, the potters of Ohio cooperated most willingly, as will be seen by a comparison of the figures for that State for 1896 and 1897.

In the following table is given a statement of the value of the pottery products of the United States, by States, in 1897, as reported to this office:

Value of pottery products of the United States in 1897, by States.

State.	Earthenware and stoneware.	Yellow and Rockingham ware.	C. C. and white granite ware.	Sanitary ware.	Porcelain or china.	Porcelain electrical supplies.	Total.
Alabama	$32,350	....	....	....	....	....	$32,350
Arkansas	16,660	....	....	....	....	....	16,660
California	15,703	....	$17,000	....	....	....	32,703
Colorado	10,000	....	....	....	....	....	10,000
Connecticnt	71,500	....	....	....	....	....	71,500
Dist. Columbia	3,000	....	....	....	....	....	3,000
Florida	3,500	....	....	....	....	....	3,500
Georgia	10,700	....	....	....	....	....	10,700
Idaho	800	$1,000	....	....	....	....	1,800
Illinois	498,900	20,000	(*a*)	....	....	....	518,900
Indiana	29,725	18,000	200,000	$50,000	....	....	297,725
Iowa	38,641	175	....	200	....	....	39,016
Kansas	4,100	....	....	....	....	....	4,100
Kentucky	119,930	5,500	....	....	....	....	125,430
Louisiana	500	....	....	....	....	....	500
Maine	500	....	....	....	....	....	500
Maryland	124,277	7,740	....	....	$100,000	....	232,017
Massachusetts	186,515	....	40,000	....	800	$2,029	229,344
Michigan	22,300	....	....	....	....	....	22,300
Minnesota	303,875	....	....	....	....	....	303,875

a Included with Indiana's product.

Value of pottery products of the United States in 1897, by States—Continued.

State.	Earthenware and stoneware.	Yellow and Rockingham ware.	C. C. and white granite ware.	Sanitary ware.	Porcelain or china.	Porcelain electrical supplies.	Total.
Mississippi....	$12,000	....	....	....	....	....	$12,000
Missouri......	52,459	....	....	....	....	....	52,459
Montana......	529	....	....	....	....	....	529
Nebraska......	3,980	....	....	....	....	....	3,980
N. Hampshire	....	....	....	....	$18,000	$7,000	25,000
New Jersey....	407,960	$9,700	$235,058	$418,445	42,000	14,200	1,127,363
New York.....	179,265	....	....	1,000	3,000	....	183,265
North Carolina	10,170	....	....	....	3,000	....	13,170
Ohio..........	1,709,884	271,453	1,644,246	24,552	912,434	157,700	4,720,269
Oregon........	8,900	105	....	....	....	....	9,005
Pennsylvania..	426,949	100	276,350	....	....	....	703,399
South Carolina	700	....	....	....	....	....	700
Tennessee.....	40,120	....	....	....	250	....	40,370
Texas.........	62,210	....	....	....	....	....	62,210
Utah..........	1,200	....	....	....	....	....	1,200
Virginia......	7,200	....	....	....	....	....	7,200
Washington...	2,500	....	....	....	....	....	2,500
West Virginia.	169,520	....	125,000	50,000	175,000	....	519,520
Wisconsin.....	10,800	....	....	....	....	....	10,800
United States.	4,599,822	333,773	2,537,654	544,197	1,254,484	180,929	9,450,859
Per cent of total clay products	7.55	.55	4.17	.89	2.06	.30	15.52

Value of pottery products of the United States in 1896, by States.

State.	Earthenware and stoneware.	Yellow and Rockingham ware.	C. C. and white granite ware.	Sanitary ware.	Porcelain or china.	Porcelain electrical supplies.	Total.
Alabama.........	$6,425	....	....	....	....	....	$6,425
Arkansas.........	22,500	....	....	....	....	....	22,500
California........	17,022	....	....	....	....	....	17,022
Connecticut......	46,700	....	....	....	$2,000	....	48,700
Dist. Columbia...	3,000	....	....	....	....	....	3,000
Florida..........	2,300	....	....	....	....	....	2,300
Georgia..........	7,160	....	....	....	....	....	7,160
Illinois...........	401,482	$20,000	....	....	....	....	421,482
Indiana..........	51,345	....	....	$75,000	2,000	....	128,345
Iowa.............	42,710	125	....	100	....	$100	43,035

Value of pottery products of the United States in 1896, by States—Continued.

State.	Earthenware and stoneware.	Yellow and Rockingham ware.	C. C. and white granite ware.	Sanitary ware.	Porcelain or china.	Porcelain electrical supplies.	Total.
Kansas	$7,250	....	....	....	....	....	$7,250
Kentucky	85,750	$10,000	....	....	....	....	95,750
Louisiana	600	....	....	....	....	....	600
Maine	250	....	....	....	....	....	250
Maryland	27,696	....	....	....	....	....	27,696
Massachusetts	159,193	....	$45,000	....	....	$2,150	206,343
Michigan	20,150	....	....	....	....	....	20,150
Minnesota	41,436	....	....	....	....	....	41,436
Mississippi	1,000	....	....	....	....	....	1,000
Missouri	50,933	....	....	....	....	....	50,933
New Hampshire	....	....	....	....	$17,000	....	17,000
New Jersey	216,216	7,000	358,175	$376,151	2,600	109,000	1,069,142
New York	100,733	....	15,000	21,000	120,000	55,000	311,733
North Carolina	14,955	....	....	....	....	....	14,955
Ohio	1,169,788	218,392	1,127,010	139,160	245,000	....	2,899,350
Oregon	7,500	300	....	....	....	....	7,800
Pennsylvania	367,201	2,000	48,400	....	200,000	....	617,601
South Carolina	1,100	....	....	....	....	....	1,100
Tennessee	37,661	....	....	....	....	....	37,661
Texas	58,081	....	....	....	....	....	58,081
Virginia	10,440	....	....	....	....	....	10,440
Washington	1,180	....	....	....	....	....	1,180
West Virginia	130,000	....	95,047	18,412	167,248	....	410,707
Wisconsin	12,500	....	....	....	....	....	12,500
United States	3,122,257	257,817	1,688,632	629,823	755,848	166,250	6,620,627
Per cent of total clay products	5.02	.41	2.72	1.01	1.22	.27	10.65

As will be noted, the pottery products increased from $6,620,627 in 1896 to $9,450,859 in 1897, a gain of $2,830,232 or 42.74 per cent. While the pottery composed 10.65 per cent of the total clay production in 1896, in 1897 its percentage of the grand total was 15.52. This increase is due in large part to the fact that there was a much greater number of firms reporting in this branch of the industry in 1897 than in 1896, and does not indicate that the volume of business increased proportionately. Nevertheless, there was undoubtedly an increased output in the latter part of the year, because of the legislation enacted in 1897, which increased the duties on all grades of pottery.

The following table shows the rank of States in the production of pottery, together with value of the product of each State and the percentage of the total product made by each in 1896 and 1897:

Rank of States in value of pottery in 1897.

Rank.	State.	Value.	Per cent of product.
1	Ohio	$4,720,269	49.95
2	New Jersey	1,127,363	11.93
3	Pennsylvania	703,399	7.44
4	West Virginia	519,520	5.50
5	Illinois	518,900	5.49
6	Minnesota	303,875	3.21
7	Indiana	297,725	3.15
8	Maryland	232,017	2.45
9	Massachusetts	229,344	2.43
10	New York	183,265	1.94
11	Kentucky	125,430	1.33
12	Connecticut	71,500	.76
13	Texas	62,210	.66
14	Missouri	52,459	.55
15	Tennessee	40,370	.43
16	Iowa	39,016	.41
17	California	32,703	.35
18	Alabama	32,350	.34
19	New Hampshire	25,000	.26
20	Michigan	22,300	.24
21	Arkansas	16,660	.18
22	North Carolina	13,170	.14
23	Mississippi	12,000	.13
24	Wisconsin	10,800	.11
25	Georgia	10,700	.11
26	Colorado	10,000	.11
27	Oregon	9,005	.40
28	Virginia	7,200	
29	Kansas	4,100	
30	Nebraska	3,980	
31	Florida	3,500	
32	District of Columbia	3,000	
33	Washington	2,500	
34	Idaho	1,800	
35	Utah	1,200	
36	South Carolina	700	
37	Montana	529	
38	Louisiana	500	
	Maine	500	
	Total	9,450,859	100

Rank of States in value of pottery in 1896.

Rank.	State.	Value.	Per cent of product.
1	Ohio	$2,899,350	43.79
2	New Jersey	1,069,142	16.15
3	Pennsylvania	617,601	9.33
4	Illinois	421,482	6.37
5	West Virginia	410,707	6.20
6	New York	311,733	4.71
7	Massachusetts	206,343	3.12
8	Indiana	128,345	1.94
9	Kentucky	95,750	1.45
10	Texas	58,081	.88
11	Missouri	50,933	.77
12	Connecticut	48,700	.74
13	Iowa	43,035	.65
14	Minnesota	41,436	.63
15	Tennessee	37,661	.57
16	Maryland	27,696	.42
17	Arkansas	22,500	.34
18	Michigan	20,150	.30
19	California	17,022	.26
20	New Hampshire	17,000	.26
21	North Carolina	14,955	.23
22	Wisconsin	12,500	.19
23	Virginia	10,440	.16
24	Oregon	7,800	.54
25	Kansas	7,250	
26	Georgia	7,160	
27	Alabama	6,425	
28	District of Columbia	3,000	
29	Florida	2,300	
30	Washington	1,180	
31	South Carolina	1,100	
32	Mississippi	1,000	
33	Louisiana	600	
34	Maine	250	
	Total	6,620,627	100.00

The great increase here shown in the pottery product, 42.74 per cent, is due largely to the gain of Ohio, which holds first position in 1896 and 1897. The product of this State increased from $2,899,350, or 43.79 per cent of the total, in 1896, to $4,720,269, or 49.95 per cent, in 1897, a gain of $1,820,919, out of a total gain for the whole country of $2,830,237, or nearly two-thirds of this net gain.

New Jersey, which was second in both years, also made a slight advance, but it was insignificant compared with the pottery interests in this State, being $1,069,142 in 1896, or 16.15 per cent, and $1,127,363, or 11.93 per cent of the total in 1897, a gain of only $58,221. Pennsylvania also shows a slight increase, from $617,601 in 1896, or 9.33 per cent of the total, to $703,399 in 1897, or 7.44 per cent of the total.

Illinois, which was fourth in 1896, with a value of $421,482, or 6.37 per cent of the product, was fifth in 1897, although her product increased to $518,900, or 5.49 per cent of the product. West Virginia, which was fifth in 1896, was fourth in 1897, having displaced Illinois. Minnesota, which was fourteenth in 1896, jumped to sixth in 1897, and Maryland rose from sixteenth in 1896 to eighth in 1897. Alabama, which was twenty-seventh in 1896, with a value of $6,425, became eighteenth in 1897, with a value of $32,350. Mississippi's product was valued at $1,000 in 1896, which gave it a rank of thirty-second; in 1897 its rank was twenty-third, with a value of $12,000.

RAW CLAY.

In the following table is given a statement of the raw clay produced by miners who do not manufacture the clay into wares, but sell it to clay workers. The same difficulties present themselves in the collection of these statistics as of those for other branches of the clay-working industry, namely, the wide distribution of the product, the large number of producers, and the unfamiliarity of the producers with methods of making returns of production:

Production and value of raw clay in the United States in 1897, by States.

State.	Kaolin.		Ball.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Alabama	....	....	....	....
California	....	....	....	....
Colorado	550	$1,250	9,999	$11,554
Delaware	12,166	99,441	....	....
Florida	6,948	39,500	....	....
Illinois	10,029	7,154	....	....
Indiana	1,250	1,000	....	....
Kentucky	....	....	7,500	22,500
Maryland	....	....	....	7,607

Production and value of raw clay in the United States in 1897, by States—Continued.

State.	Kaolin.		Ball.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Michigan	420	$1,260	....	....
Missouri	2,498	5,901	3,000	$16,500
Montana	....	....	....	....
New Jersey	....	....	77,597	137,097
New York	873	1,642	....	2,000
North Carolina	5,000	40,000	....	....
Ohio	100	250	500	300
Pennsylvania	8,409	50,482	10,050	11,638
South Carolina	16,000	77,200	....	....
Vermont	1,000	7,000	....	....
West Virginia	....	....	4,280	4,370
Wisconsin	3,500	35,000	....	....
Total	68,743	367,080	112,926	213,566

State.	Fire.		Total.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Alabama	....	$4,000	....	$4,000
California	3,700	4,250	3,700	4,250
Colorado	7,463	9,713	18,012	22,517
Delaware	....	....	12,166	99,441
Florida	....	....	6,948	39,500
Illinois	17,022	14,622	27,051	21,776
Indiana	3,500	3,500	4,750	4,500
Kentucky	....	....	7,500	22,500
Maryland	....	....	....	7,607
Michigan	....	....	420	1,260
Missouri	177,600	178,600	183,098	201,001
Montana	1,087	1,087	1,087	1,087
New Jersey	105,679	121,879	183,276	258,976
New York	14,577	14,669	15,450	18,311
North Carolina	....	....	5,000	40,000
Ohio	10,861	8,398	11,461	8,948
Pennsylvania	21,957	22,084	40,416	84,204
South Carolina	3,000	6,000	19,000	83,200
Vermont	....	....	1,000	7,000
West Virginia	15,000	9,000	19,280	13,370
Wisconsin	....	....	3,500	35,000
Total	381,446	397,802	563,115	978,448

THE CLAY INDUSTRY IN INDIVIDUAL STATES.

The following series of tables show the output and value of clay products in the more important clay-working States from 1894 to 1897, inclusive, and will be interesting as a means of comparing the products of each State for a term of years.

The statistics of the pottery industry, except of stoneware, were not collected by this office prior to 1896, which accounts for the blanks under this head in 1894 and 1895.

CALIFORNIA.

Clay products of California from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	94, 561, 000	144, 403, 000	74, 240, 000	88, 890, 000
Value	$627, 235	$922, 712	$391, 567	$509, 955
Average per M	$6. 63	$6. 40	$5. 27	$5. 73
Pressed—				
Quantity	(*a*)	3, 885, 000	1, 039, 000	843, 000
Value	....	$71, 286	$34, 424	$31, 950
Average per M	....	$18. 34	$33. 13	$37. 80
Vitrified—				
Quantity	110, 000	....	120, 000	30, 000
Value	$2, 150	....	$1, 400	$450
Average per M	$19. 55	....	$11. 66	$15. 00
Fancy ......value	$14, 350	$13, 654	$6, 691	$6, 400
Fire brick ....do	$2, 575	$10, 836	$11, 875	$7, 720
Tile, not drain ....do	....	$58, 450	....	....
Draintile ....do	$15, 850	$8, 980	$4, 528	$5, 300
Sewer pipe ....do	$102, 950	$261, 536	$208, 000	$90, 430
Ornamental terra cotta, value	$23, 085	$48, 300	$2, 000	$300
Fireproofing ....value	....	....	$2, 700	$2, 000
Pottery:				
Earthenware and stoneware.value	....	....	$17, 022	$15, 703
C. C. and white granite ...value	....	....	....	$17, 000
Miscellaneous.....do	$53, 300	$25, 400	....	$4, 697
Total value	$841, 495	$1, 421, 154	$680, 207	$691, 905
Number of firms reporting	70	94	91	92
Rank of State	16	10	20	21

a Common and pressed brick not separately classified in 1894.

CONNECTICUT AND RHODE ISLAND.

Clay products of Connecticut and Rhode Island, from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	130,300,000	146,550,000	194,995,000	200,130,000
Value	$789,650	$817,462	$1,141,738	$1,017,250
Average per M	$6.06	$5.57	$5.85	$5.00
Pressed—				
Quantity	(*a*)	3,150,000	3,090,000	3,200,000
Value	....	$49,500	$46,900	$89,400
Average per M	....	$15.71	$15.17	$27.93
Vitrified—				
Quantity	301,000	4,000,000	4,020,000	4,015,000
Value	$33,850	$48,000	$48,400	$50,270
Average per M	$11.24	$12.00	$12.03	$12.52
Fancy or ornamental value	$15,000	$10,600	$10,000	$16,500
Fire brick do	$60,500	$67,000	$74,800	$44,750
Draintile do	$500	$1,000	$14,100	$1,000
Sewer pipe do	$15,000	$4,500	$2,460	....
Ornamental terra cotta, value	$60,100	$44,563	$30,000	$10,000
Fire proofing value	....	....	$500	$21,000
Tile, not drain do	$13,000	$16,000	$31,000	$15,000
Pottery:				
Earthenware and stoneware value	....	$2,800	$48,700	$71,500
Miscellaneous do	$24,000	$67,500	....	....
Total value	$1,011,600	$1,128,925	$1,448,598	$1,336,670
Number of firms reporting	45	45	48	60
Rank of Connecticut	20	20	11	10
Rank of Rhode Island	29	29	30	

a Common and pressed brick not separately classified in 1894.

GEORGIA.

Clay products of Georgia from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	110,218,000	135,480,000	132,469,000	134,296,000
Value	$585,693	$655,275	$615,771	$599,158
Average per M ..	$5.31	$4.83	$4.64	$4.46
Pressed—				
Quantity	(*a*)	4,783,000	2,390,000	3,340,000
Value	....	$46,265	$21,678	$35,381
Average per M ..	....	$9.69	$9.07	$10.59
Vitrified—				
Quantity	....	5,000	390,000	250,000
Value	....	$40	$5,660	$2,500
Average per M ..	....	$8.00	$14.51	$10.00
Fancy or ornamental .... value ..	$14,048	$27,560	$1,000	$1,000
Fire brick .... do	$17,650	$29,950	$25,297	$12,904
Drain tile .... do	$2,000	$5,200	$8,740	$5,000
Sewer pipe (*b*) ... do	$122,300	$134,700	$172,662	$242,450
Ornamental terra cotta, value	$11,000	$34,850	$32,280	$34,600
Fireproofing .... value ..	....	....	$15,565	$15,000
Tile, not drain ... do	....	$2,530	....	$320
Pottery:				
Earthenware and stoneware .. value ..	....	$6,000	$7,160	$10,700
Miscellaneous .... do	$22,196	$5,285	....	....
Total value	$774,887	$947,655	$905,813	$959,013
Number of firms reporting	64	76	88	72
Rank of State	18	15	15	14

a Common and pressed brick not separately classified in 1894.
b Including Tennessee's product.

ILLINOIS.

Clay products of Illinois from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	825,845,000	717,079,000	586,506,000	516,263,000
Value	$4,495,613	$3,786,747	$2,831,752	$2,376,498
Average per M	$5.44	$5.28	$4.83	$4.60
Pressed—				
Quantity	(*a*)	29,093,000	21,995,000	24,342,000
Value	....	$330,318	$196,658	$218,788
Average per M	....	$11.35	$8.94	$9.39
Vitrified—				
Quantity	109,700,000	82,526,000	60,955,000	87,169,000
Value	$843,217	$643,997	$486,519	$719,371
Average per M	$7.69	$7.80	$7.98	$8.25
Fancy or ornamental .... value	$72,920	$19,500	$52,624	$61,067
Fire brick ... do	$116,904	$117,040	$125,408	$106,377
Drain tile .... do	$1,418,572	$1,028,581	$517,684	$531,993
Sewer pipe .... do	$308,963	$389,680	$187,350	$165,071
Ornamental terra cotta, value	$430,000	$722,500	$720,100	$418,500
Fireproofing .... value	$81,288	$71,685	$213,315	$177,782
Tile, not drain .... do	$44,144	$231,166	$110,355	$97,000
Pottery:				
Earthenware and stoneware .. value	....	$255,540	$401,482	$498,900
Yellow and Rockingham ware ... value	....	....	$20,000	$20,000
Miscellaneous .... do	$662,739	$23,130	....	$7,227
Total value	$8,474,360	$7,619,884	$5,863,247	$5,398,574
Number of firms reporting	697	678	836	769
Rank of State	2	3	4	4

a Common and pressed brick not separately classified in 1894.

INDIANA.

Clay products of Indiana from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	335, 868, 000	319, 751, 000	262, 936, 000	224, 042, 000
Value	$1, 720, 017	$1, 488, 370	$1, 207, 247	$1, 012, 547
Average per M .	$5. 12	$4. 65	$4. 59	$4. 52
Pressed—				
Quantity	(*a*)	17, 085, 000	9, 071, 000	8, 394, 000
Value	....	$161, 336	$99, 954	$94, 935
Average per M .	....	$9. 44	$11. 01	$11. 30
Vitrified—				
Quantity	23, 936, 000	22, 313, 000	18, 792, 000	27, 239, 000
Value	$224, 473	$204, 000	$175, 670	$266, 638
Average per M .	$9. 38	$9. 14	$9. 35	$9. 78
Fancy or ornamental........value..	$6, 650	$13, 439	$36, 050	$3, 650
Fire brick ...do....	$22, 720	$12, 510	$28, 350	$24, 245
Draintile ....do....	$954, 264	$820, 602	$475, 919	$559, 524
Sewer pipe.......do....	$1, 000	$42, 000	$125, 839	$156, 450
Ornamental terra cotta, value	$50, 000	$52, 600	$65, 150	$31, 000
Fireproofing ....value..	$50, 000	$60, 000	$136, 461	$121, 835
Tile, not drain ...do....	$101, 855	$139, 463	$175, 390	$223, 750
Pottery:				
Earthenware and stoneware.value..	....	$11, 400	$51, 345	$29, 725
Yellow and Rockingham ware.value..	....	....	....	$18, 000
C. C. and white granite ...value..	....	....	....	(*b*) $200, 000
Sanitary ware.do...	....	....	$75, 000	$50, 000
Porcelain or china, value	....	....	$2, 000	....
Miscellaneous ...value..	$4, 590	$111, 890	$19, 950	$20, 010
Total value	$3, 135, 569	$3, 117, 520	$2, 674, 325	$2, 812, 309
Number of firms reporting	663	659	827	793
Rank of State	6	6	7	6

a Pressed brick not separately classified in 1894.

b Including Illinois' product.

IOWA.

Clay products of Iowa from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	208,195,000	180,664,000	172,195,000	152,446,000
Value	$1,317,473	$1,095,074	$1,003,624	$850,834
Average per M	$6.33	$6.06	$5.83	$5.58
Pressed—				
Quantity	(*a*)	11,159,000	6,088,000	7,823,000
Value	....	$87,130	$47,386	$57,230
Average per M	....	$7.81	$7.78	$7.31
Vitrified—				
Quantity	45,488,000	31,704,000	14,385,000	56,315,000
Value	$376,951	$243,928	$112,985	$426.056
Average per M	$8.29	$7.69	$7.85	$7.56
Fancy or ornamental .... value	$2,950	$2,300	....	$2,800
Fire brick ... do	$36,525	$5,920	$5,198	$8,700
Draintile .... do	$557,312	$290,515	$225,650	$372,070
Sewer pipe .... do	$58,000	$55,131	$73,039	$44,300
Ornamental terra cotta, value	$50	$2,800	$800	$500
Fireproofing .... value	$500	$400	$7,685	$7,540
Tile, not drain ... do	$8,545	$16,094	$2,000	$6,700
Pottery:				
Earthenware and stoneware. value	....	$25,600	$42,710	$38,641
Yellow and Rockingham ware. value	....	....	$125	$175
Sanitary ..... do	....	....	$100	$200
Porcelain and electrical supplies, value	....	....	$100	....
Miscellaneous ... value	$21,200	$45,400	$173,000	$5,501
Total value	$2,379,506	$1,870,292	$1,694,402	$1,821,247
Number of firms reporting	437	412	519	427
Rank of State	8	9	9	9

a Pressed brick not separately classified in 1894.

KENTUCKY.

Clay products of Kentucky from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	84,498,000	86,521,000	63,675,000	71,642,000
Value	$418,886	$455,927	$317,749	$355,313
Average per M	$4.96	$5.27	$4.99	$4.96
Pressed—				
Quantity	(*a*)	1,800,000	1,475,000	2,349,000
Value	....	$14,240	$15,550	$19,390
Average per M	....	$7.91	$10.54	$8.25
Vitrified—				
Quantity	6,256,000	3,850,000	7,000,000	1,500,000
Value	$51,389	$33,150	$70,000	$13,500
Average per M	$8.21	$8.61	$10.00	$9.00
Fancy brick..value	$50,700	$150	....	....
Fire brick ....do	$87,800	$126,539	$168,210	$157,499
Draintile ....do	$31,400	$17,322	$24,750	$28,065
Sewer pipe........do	$15,000	$25,000	$55,000	$21,200
Fireproofing ......do	....	....	$7,800	$971
Tile, not drain ....do	$60,000	$75,000	$76,000	$85,000
Pottery:				
Earthenware and stoneware .value	....	$30,120	$85,750	$119,930
Yellow and Rockingham ware, value	....	....	$10,000	$5,500
Miscellaneous	$44,500	$61,750	....	....
Total value	$759,675	$839,198	$830,809	$806,368
Number of firms reporting	87	92	125	114
Rank of State	19	19	18	17

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[a] Common and pressed brick not separately classified in 1894.

MAINE.

Clay products of Maine from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	72, 302, 000	72, 594, 000	68, 604, 000	53, 133, 000
Value	$401, 982	$403, 217	$375, 353	$273, 929
Average per M	$5. 56	$5. 55	$5. 47	$5. 16
Pressed—				
Quantity	(*a*)	1, 370, 000	1, 695, 000	1, 280, 000
Value	....	$13, 520	$15, 650	$11, 200
Average per M	....	$9. 86	$9. 23	$8. 75
Vitrified—				
Quantity	1, 650, 000	....	20, 000	96, 000
Value	$11, 200	....	$340	$1, 301
Average per M	$6. 79	....	$17. 00	$13. 55
Fancy brick . value	$200	$4, 400	$2, 450	....
Fire brick ....do	$20, 000	$37, 501	$42, 000	$37, 218
Draintile ....do	$8, 400	$5, 168	$4, 738	$3, 900
Sewer pipe.........do	$390, 000	$270, 177	$551, 613	$473, 191
Ornamental terra cotta, value	....	$3, 121	$1, 337	....
Fireproofing ......do	....	....	$1, 000	....
Pottery:				
Earthenware and stoneware . value	....	....	$250	$500
Total value	$831, 782	$737, 104	$994, 731	$801, 239
Number of firms reporting	109	95	117	110
Rank of State	17	21	13	18

a Common and pressed brick not separately classified in 1894.

MARYLAND.

Clay products of Maryland from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	141,055,000	117,016,000	144,519,000	116,841,000
Value	$974,669	$743,023	$987,706	$702,957
Average per M	$6.91	$6.35	$6.83	$6.02
Pressed—				
Quantity	(*a*)	2,555,000	4,572,000	5,316,000
Value	....	$35,229	$97,426	$92,344
Average per M	....	$13.78	$21.35	$17.37
Vitrified—				
Quantity	50,000	8,000	186,000	150,000
Value	$470	$80	$2,382	$1,200
Average per M	$9.40	$10.00	$12.80	$8.00
Fancy brick . value	$1,100	$1,000	$37,300	$35,100
Fire brick ....do	$164,848	$232,270	$150,655	$141,650
Draintile ....do	$3,050	$3,079	$1,945	$25,524
Sewer pipe ....do	$20	....	....	....
Ornamental terra cotta ....value	$50	$6,781	$5,075	$6,000
Tile, not drain ....do	$23,500	$12,000	$27,003	$18,470
Pottery:				
Earthenware and stoneware . value	....	....	$27,696	$124,277
Yellow and Rockingham ware . value	....	....	....	$7,740
Porcelain or China, value	....	....	....	$100,000
Miscellaneous	177,158	$33,525	$112,867	$47,020
Total value	1,344,865	$1,066,987	$1,450,055	$1,302,282
Number of firms reporting	67	65	137	122
Rank of State	11	13	10	11

a Common and pressed brick not separately classified in 1894.

MASSACHUSETTS.

Clay products of Massachusetts from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	263, 732, 000	245, 423, 000	274, 956, 000	257, 539, 000
Value	$1, 648, 065	$1, 443, 677	$1, 601, 537	$1, 457, 683
Average per M	$6. 25	$5. 88	$5. 82	$5. 66
Pressed—				
Quantity	(*a*)	8, 509, 000	4, 240, 000	6, 946, 000
Value	....	$200, 234	$109, 780	$126, 420
Average per M	....	$23. 53	$25. 89	$18. 20
Vitrified—				
Quantity	1, 854, 000	100, 000	....	....
Value	$14, 530	$800	....	....
Average per M	$7. 84	$8. 00	....	....
Fancy brick. value	$139, 100	$91, 675	$88, 000	$74, 500
Fire brick....do	$93, 825	$187, 710	$131, 950	$184, 665
Draintile ....do	....	....	....	$260
Ornamental terra cotta, value	$48, 000	$65, 000	$52, 164	$30, 430
Fireproofing ....value	$50, 000	$63, 668	$73, 000	$70, 000
Tile, not drain...do	$46, 983	$900	$200	$500
Pottery:				
Earthenware and stoneware. value	....	$1, 800	$159, 193	$186, 515
C.C. and white granite ware ..value	....	....	$45, 000	$40, 000
Porcelain or china, value	....	....	....	$800
Porcelain electrical supplies ..value	....	....	$2, 150	$2, 029
Miscellaneous....do	$299, 431	$166, 126	....	$5, 594
Total value	$2, 339, 934	$2, 221, 590	$2, 262, 974	$2, 179, 396
Number of firms reporting	114	112	123	138
Rank of State	9	8	8	8

a Common and pressed brick not separately classified in 1894.

MICHIGAN.

Clay products of Michigan from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	174,881,000	168,574,000	110,523,000	120,377,000
Value	$924,872	$767,203	$590,095	$546,638
Average per M	$5.29	$4.55	$5.34	$4.54
Pressed—				
Quantity	(*a*)	6,530,000	2,157,000	1,990,000
Value	....	$47,719	$13,827	$10,515
Average per M	....	$7.31	$6.41	$5.28
Vitrified—				
Quantity	145,000	1,300,000	3,650,000	1,905,000
Value	$1,560	$12,755	$40,750	$22,332
Average per M	$10.76	$9.81	$11.16	$11.72
Fancy brick. value	$54,750	$5,850	$4,600	$1,000
Fire brick ... do	$401,880	$3,575	$2,300	$210
Draintile ... do	$741,327	$200,893	$225,293	$165,564
Sewer pipe ... do	$99,040	$76,000	$105,140	$20,361
Ornamental terra cotta, value	....	....	$750	....
Fireproofing .... value	....	....	$2,450	$2,200
Tile, not drain ... do	$4,300	$2,900	$50	$150
Pottery:				
Earthenware and stoneware. value	....	....	$20,150	$22,300
Miscellaneous .... do	$26,600	$12,300	....	$600
Total value	$2,254,329	$1,129,195	$1,005,405	$791,870
Number of firms reporting	196	200	238	200
Rank of State	10	11	12	19

a Common and pressed brick not separately classified in 1894.

MINNESOTA.

Clay products of Minnesota from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	98, 957, 000	127, 244, 000	87, 844, 000	79, 474, 000
Value	$473, 904	$578, 345	$398, 872	$366, 734
Average per M	$4. 79	$4. 55	$4. 54	$4. 61
Pressed—				
Quantity	(*a*)	5, 061, 000	2, 839, 000	29, 650, 000
Value	....	$30, 635	$21, 368	$31, 750
Average per M	....	$6. 05	$7. 52	$10. 71
Vitrified—				
Quantity	....	....	3, 000	530, 000
Value	....	....	$75	$5, 900
Average per M	....	....	$25. 00	$11. 13
Fancy brick. value	$1, 340	$500	$100	$600
Fire brick ...do	$3, 950	$2, 000	$1, 375	$5, 550
Draintile ....do	$77, 300	$2, 775	$5, 240	$3, 810
Sewer pipe ......do	$218, 266	$169, 761	$117, 620	$117, 650
Ornamental terra cotta, value	....	....	....	$1, 200
Fireproofing .....do	$34, 500	$49, 000	$10, 290	$34, 000
Tile, not drain ...do	....	$570	$325	$200
Pottery:				
Earthenware and stoneware. value	....	$246, 115	$41, 436	$303, 875
Miscellaneous....do	$111, 250	$20, 434	....	....
Total value	$920, 510	$1, 100, 135	$596, 701	$871, 269
Number of firms reporting	122	126	146	117
Rank of State	15	12	22	15

a Common and pressed brick not separately classified in 1894.

MISSOURI.

Clay products of Missouri from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	258,922,000	234,201,000	263,037,000	221,102,000
Value	$1,541,553	$1,251,200	$1,317,916	$999,352
Average per M	$5.95	$5.34	$5.00	$4.52
Pressed—				
Quantity	(*a*)	29,674,000	31,260,000	21,537,000
Value	....	$275,725	$293,193	$224,016
Average per M	....	$9.29	$9.37	$10.40
Vitrified—				
Quantity	23,189,000	6,816,000	7,500,000	19,620,000
Value	$190,220	$54,640	$61,500	$182,625
Average per M	$8.20	$8.01	$8.20	$9.31
Fancy ...... value	$47,933	$1,500	$136,964	$86,723
Fire brick .... do	$202,722	$484,415	$328,148	$157,502
Drain tile .... do	$172,220	$15,820	$23,383	$25,800
Sewer pipe .... do	$150,000	$212,000	$171,652	$458,368
Ornamental terra cotta, value	$225	....	$11,000	$11,000
Fireproofing .... value	....	$25,300	$44,956	$14,404
Tile (not drain) .. do	$24,679	$94,504	$14,400	$8,320
Pottery:				
Earthenware and stoneware. value	....	$8,400	$50,933	$52,459
Miscellaneous .... do	$286,026	$375,714	$226,200	$175,959
Total value	$2,615,578	$2,799,218	$2,680,245	$2,396,528
Number of firms reporting	242	221	290	280
Rank of State	7	7	6	7

a Common and pressed brick not separately classified in 1894.

NEW JERSEY.

Clay products of New Jersey from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	317,260,000	248,831,000	237,781,000	263,641,000
Value	$1,601,096	$1,097,063	$950,113	$1,188,191
Average per M	$5.05	$4.40	$3.99	$4.51
Pressed—				
Quantity	(*a*)	18,417,000	15,655,000	30,022,000
Value	....	$387,737	$340,919	$670,282
Average per M	....	$21.05	$21.77	$22.33
Vitrified—				
Quantity	400,000	2,500,000	2,575,000	550,000
Value	$6,000	$30,000	$35,600	$7,300
Average per M	$15.00	$12.00	$13.82	$13.27
Fancy brick . value	$257,300	$179,828	$188,819	$170,721
Fire brick ... do	$502,430	$456,825	$604,983	$277,670
Drain tile ... do	$8,600	$14,024	$37,850	$11,225
Sewer pipe ... do	$137,977	$101,316	$16,205	$31,973
Ornamental terra cotta, value	$88,000	$763,420	$618,502	$539,512
Fireproofing ... value	$206,471	$285,165	$721,694	$987,637
Tile (not drain) .. do	$701,955	$850,014	$143,292	$191,735
Pottery:				
Earthenware and stoneware . value	....	$162,946	$216,216	$407,960
Yellow and Rockingham ware, value	....	....	$7,000	$9,700
C. C. and white granite ware, value	....	....	$358,175	$235,058
Sanitary ware, value	....	....	$376,151	$418,445
Porcelain or China, value	....	....	$2,600	$42,000
Porcelain electrical supplies .. value	....	....	$109,000	$14,200
Miscellaneous	$466,726	$570,782	$884	$118.888
Total value	$3,976,555	$4,899,120	$4,728,003	$5,322.497
Number of firms reporting	129	130	140	150
Rank of State	5	5	5	5

a Common and pressed brick not separately classified in 1894.

NEW YORK.

Clay products of New York from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	821,286,000	955,442,000	931,565,000	828,868,000
Value	$3,945,022	$4,396.027	$4,141,973	$3,657,750
Average per M	$4.80	$4.60	$4.45	$4.41
Pressed—				
Quantity	(*a*)	18,437,000	18,409,000	18,046,000
Value	....	$290,910	$298,515	$263,166
Average per M	....	$15.78	$16.22	$14.58
Vitrified—				
Quantity	9,304,000	10,896,000	23,723,000	28,145,000
Value	$136,697	$121,892	$259,550	$309,564
Average per M	$14.69	$11.19	$10.94	$11.00
Fancy brick. value	$52,500	$1,025	$17,854	$2.680
Fire brick....do	$298,578	$302,407	$345,485	$339,740
Drain tile........do	$62,955	$56,740	$292,954	$25,385
Sewer pipe.......do	$10,000	$133,000	$85,289	$116,000
Ornamental terra cotta, value	$508,000	$336,000	$484,113	$420,601
Fireproofing ....value	$828	....	$72,410	$56,410
Tile (not drain)..do	$64,704	$143,465	$99,060	$150,360
Pottery:				
Earthenware and stoneware. value	....	$44,033	$100,733	$179,265
C. C. and white granite ware, value	....	....	$15,000	....
Sanitary ware, value	....	....	$21,000	$1,000
Porcelain or china, value	....	....	$120,000	$3,000
Porcelain electrical supplies ..value	....	....	$55,000	....
Miscellaneous	$84,738	$63,997	$5,270	$90,583
Total value	$5,164,022	$5,889,496	$6,414,206	$5,615,504
Number of firms reporting	302	280	295	311
Rank of State	4	4	3	3

a Common and pressed brick not separately classified in 1894.

OHIO.

Clay products of Ohio from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity.......	386,712,000	381,065,000	313,995,000	290,522,000
Value...........	$2,136,691	$1,887,023	$1,516,088	$1,358,333
Average per M..	$5.53	$4.95	$4.83	$4.68
Pressed—				
Quantity.......	(*a*)	44,396,000	29,890,000	36,229.000
Value...........	....	$518.717	$337,567	$357,613
Average per M..	....	$11.68	$11.29	$9.87
Vitrified—				
Quantity.......	113,329,000	96,555,000	72,254,000	85,665,000
Value...........	$928,948	$787,878	$619,463	$597,905
Average per M..	$8.20	$8.16	$8.57	$6.98
Fancy brick.value..	$92,683	$57,767	$62,982	$104,426
Fire brick.....do...	$742,304	$696,175	$575,748	$510,878
Drain tile..........do...	$1,465,586	$884,638	$569,871	$737,754
Sewer pipe.........do...	$3,311,895	$1,746,503	$2,058,210	$1,495,974
Ornamental terra cotta, value	$19,000	$49,678	$63,100	$37,159
Fireproofing....value..	....	$59,600	$279,264	$314,800
Tile, not drain ....do...	$476,118	$797,985	$805,198	$113,353
Pottery:				
Earthenware and stoneware.value..	....	$563,355	$1,169,788	$1,709,884
Yellow and Rockingham ware.value..	....	....	$218,392	$271,453
C. C. and white granite ware, value	....	....	$1,127,010	$1,644,246
Sanitary ware, value	....	....	$139,160	$24,552
Porcelain or china, value	....	....	$245,000	$912,434
Porcelain electrical supplies ..value..	....	....	....	$157,700
Miscellaneous.....do...	$1,495,273	$2,600,063	$162,730	$269,220
Total	$10,668,498	$10,649,382	$9,949,571	$10,617,684
Number of firms reporting	968	980	1,021	1,035
Rank of State..........	1	1	1	1

a Common and pressed brick not separately classified in 1894.

PENNSYLVANIA.

Clay products of Pennsylvania from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	642, 326, 000	612, 492, 000	675, 444, 000	558, 084, 000
Value	$4, 173, 274	$3, 570, 536	$4, 118, 206	$3, 178, 190
Average per M	$6.50	$5.82	$6.10	$5.69
Pressed—				
Quantity	(*a*)	56, 810, 000	47, 213, 000	73, 627, 000
Value	....	$1, 018, 682	$662, 188	$873, 057
Average per M	....	$17.93	$14.03	$11.86
Vitrified—				
Quantity	74, 029, 000	36, 268, 000	47, 229, 000	41, 620, 000
Value	$521, 359	$305, 035	$404, 182	$336, 413
Average per M	$7.04	$8.41	$8.57	$8.08
Fancy brick . value	$75, 281	$48, 032	$30, 545	$61, 830
Fire brick.....do	$1, 568, 545	$2, 250, 790	$2, 083, 414	$1, 707, 621
Drain tile.........do	$61, 952	$13, 320	$49, 039	$14, 164
Sewer pipe........do	$347, 202	$360, 475	$323, 239	$283, 451
Ornamental terra cotta, value	$61, 000	$263, 000	$142, 200	$157, 000
Fireproofing ....value	$75, 000	$120, 508	$104, 401	$92, 880
Tile, not drain.....do	$67, 300	$95, 529	$122, 707	$110, 620
Pottery:				
Earthenware and stoneware . value	....	$208, 130	$367, 201	$426, 949
Yellow and Rockingham ware . value	....	....	$2, 000	$100
C. C. and white granite ware, value	....	....	$48, 400	$276, 350
Porcelain or china, value	....	....	$200, 000	....
Miscellaneous	$477, 135	$553, 124	$405, 591	$356, 070
Total	$7, 428, 048	$8, 807, 161	$9, 063, 313	$7, 874, 695
Number of firms reporting	508	513	536	567
Rank of State	3	2	2	2

a Common and pressed brick not separately classified in 1894.

TENNESSEE.

Clay products of Tennessee from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	70,519,000	69,034,000	65,548,000	81,241,000
Value	$417,616	$355,420	$364,463	$406,236
Average per M	$5.92	$5.14	$5.56	$5.00
Pressed—				
Quantity	(a)	2,633,000	7,881,000	5,154,000
Value	....	$25,352	$66,865	$41,351
Average per M	....	$9.62	$8.48	$8.02
Vitrified—				
Quantity	7,687,000	....	7,503,000	6,045,000
Value	$39,384	....	$54,030	$37,813
Average per M	$5.12	....	$7.20	$6.25
Fancy brick . value	$2,971	$356	$685	$4,026
Fire brick ....do	$30,873	$24,956	$4,372	$35,497
Drain tile ....do	$25,900	$6,850	$8,575	$27,950
Sewer pipe........do	(b)	(b)	(b)	(b)
Ornamental terra cotta, value	....	$5,000	....	....
Fireproofing ....value	$15,300	....	....	$19,050
Tile, not drain ....do	....	....	$674	....
Pottery:				
Earthenware and stoneware . value	....	$24,300	$37,661	$40,120
Porcelain or china, value	....	....	....	$250
Miscellaneous	$27,300	....	....	....
Total	$559,344	$442,234	$537,325	$612,293
Number of firms reporting	76	90	101	116
Rank of State	22	24	23	22

[a] Common and pressed brick not separately classified in 1894.

[b] Included with Georgia.

TEXAS.

Clay products of Texas from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	134,963,000	138,465,000	113,027,000	107,294,000
Value	$895,359	$805,772	$665,091	$630,009
Average per M	$6.63	$5.81	$5.88	$5.87
Pressed—				
Quantity	(*a*)	16,143,000	12,891,000	19,177,000
Value	....	$103,255	$142,500	$147,958
Average per M	....	$6.39	$11.05	$7.72
Vitrified—				
Quantity	100,000	1,492,000	1,400,000	3,635,000
Value	$1,000	$12,466	$9,200	$32,475
Average per M	$10.00	$8.36	$6.57	$8.93
Fancy brick.value	$16,989	$1,024	$3,150	$1,060
Fire brick ...do	$87,360	$7,060	$8,315	$23,235
Draintile ....do	$10,049	....	$2,040	$4,180
Sewer pipe.......do	$2,000	$4,450	$21,626	$48,115
Ornamental terra cotta, value	....	$300	....	$100
Fireproofing....value	....	$5,000	....	$2,050
Tile, not drain... do	....	$519	$1,135	....
Pottery:				
Earthenware and stoneware.value	....	$46,600	$58,081	$62,210
Miscellaneous.....do	$16,096	$44,000	$4,615	$245,647
Total value	$1,028,853	$1,030,446	$915,753	$1,197,039
Number of firms reporting	124	136	149	184
Rank of State	13	14	14	12

a Common and pressed brick not separately classified in 1894.

VIRGINIA.

Clay products of Virginia from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	112,488,000	96,407,000	101,311,000	94,782,000
Value	$779,285	$560,316	$604,161	$574,269
Average per M.	$6.93	$5.81	$5.96	$6.06
Pressed—				
Quantity	(a)	11,176,000	13,087,000	11,037,000
Value	....	$204,078	$195,046	$153,422
Average per M.	....	$18.25	$14.90	$13.90
Vitrified—				
Quantity	5,400,000	3,000,000	7,240,000	3,000,000
Value	$52,750	$30,000	$30,000	$30,000
Average per M.	$9.77	$10.00	$4.14	$10.00
Fancy brick . value	$76,474	$36,919	$24,283	$29,000
Fire brick ... do	$4,794	$1,750	$2,678	$2,755
Drain tile ... do	$10,705	$4,980	$2,918	$1,800
Sewer pipe ... do	....	$1,000	....	....
Ornamental terra cotta, value	....	....	....	$1,100
Tile (not drain) . value	$6,696	$700	....	$500
Pottery:				
Earthenware and stoneware . value	....	$3,025	$10,440	$7,200
Miscellaneous ... do	$6,889	$13,000	$10,000	$12,000
Total value	$937,593	$855,768	$879,526	$812,046
Number of firms reporting	104	111	114	101
Rank of State	14	18	17	16

[a] Common and pressed brick not separately classified in 1894.

WEST VIRGINIA.

Clay products of West Virginia from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	38,719,000	35,815,000	29,462,000	30,594,000
Value	$227,032	$208,337	$164,831	$164,177
Average per M	$5.86	$5.82	$5.59	$5.37
Pressed—				
Quantity	(*a*)	1,845,000	972,000	2,033,000
Value	....	$18,400	$11,370	$19,246
Average per M	....	$9.97	$11.70	$9.47
Vitrified—				
Quantity	8,059,000	62,330,000	21,485,000	38,271,000
Value	$63,964	$449,388	$177,856	$289,886
Average per M	$7.94	$7.21	$8.28	$7.57
Fancy brick. value	$1,000	$4,262	$32,237	$9,500
Fire brick ....do	$500	$4,000	$1,500	$28,696
Draintile ....do	$360	$140	$22,972	$400
Sewer pipe ....do	$350,000	$196,000	$77,171	$81,629
Ornamental terra cotta, value	$10,000	$250	....	$1,500
Tile, not drain...value	....	....	....	$700
Pottery:				
Earthenware and stoneware. value	....	$3,000	$130,000	$169,520
C.C. and white granite ware...value	....	....	$95,047	$125,000
Sanitary ware. do	....	....	$18,412	$50,000
Porcelain or china, value	....	....	$167,248	$175,000
Miscellaneous...value	$20,150	$12,000	$4,300	....
Total value	$673,006	$895,777	$902,944	$1,115,254
Number of firms reporting	36	46	45	55
Rank of State	21	17	16	13

a Common and pressed brick not separately classified in 1894.

WISCONSIN.

Clay products of Wisconsin from 1894 to 1897.

	1894.	1895.	1896.	1897.
Brick:				
Common—				
Quantity	181, 287, 000	141, 018, 000	116, 001, 000	134, 025, 000
Value	$1, 099, 102	$782, 552	$662, 617	$640, 592
Average per M	$6.06	$5.54	$5.71	$4.78
Pressed—				
Quantity	(*a*)	12, 530, 000	5, 404, 000	6, 243, 000
Value	....	$123, 505	$48, 671	$48, 670
Average per M	....	$9.85	$9.00	$7.80
Fancy brick..value.	$19, 324	$3, 425	$15, 710	$3, 120
Fire brick ....do...	$6, 200	$1, 200	....	$4, 000
Draintile ....do...	$85, 150	$32, 314	$27, 797	$27, 750
Sewer pipe........do...	....	....	$20, 000	....
Tile (not drain)...do...	$1, 300	....	$500	....
Pottery:				
Earthenware and stoneware.value..	....	....	$12, 500	$10, 800
Miscellaneous	$44, 300	$1, 200	$1, 200	$150
Total	$1, 255, 376	$944, 196	$788, 995	$735, 082
Number of firms reporting	140	146	157	164
Rank of State	12	16	19	20

a Common and pressed brick not separately classified in 1894.

IMPORTS.

In the following tables will be found a statement of the clay and manufactured goods imported into the United States in recent years:

Classified imports of clay from 1885 to 1897.

Calendar year—	Kaolin or china clay.		All other clays.						Totals.	
			Unwrought.		Wrought.		Common blue.			
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Long tons.		*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
1885......	10,626	$83,722	9,736	$76,899	3,554	$29,839	....	....	23,916	$190,460
1886......	16,590	123,093	13,740	113,875	1,654	20,730	....	....	31,984	257,698
1887......	23,486	141,360	17,645	139,405	2,187	22,287	....	....	43,318	303,052
1888......	18,150	102,050	20,604	152,694	6,832	53,245	....	....	45,586	307,989
1889......	19,843	113,538	19,237	145,983	8,142	64,971	....	....	47,222	324,492
1890......	29,923	270,141	21,049	155,486	2,978	29,143	....	....	53,950	454,770
1891......	39,901	294,458	16,094	118,689	6,297	56,482	....	....	62,292	469,629
1892......	49,468	375,175	20,132	155,047	4,551	64,818	5,172	$59,971	79,323	655,011
1893......	49,713	374,460	14,949	113,029	6,090	67,280	4,304	51,889	75,056	606,658
1894......	62,715	465,501	13,146	98,776	4,768	60,786	2,528	28,886	83,157	653,949
1895......	75,447	531,714	18,419	125,417	5,160	60,775	3,869	40,578	102,895	758,484
1896......	76,718	536,081	13,319	88,029	4,514	56,701	4,983	54,695	99,534	735,506
1897......	71,938	493,431	9,405	56,264	7,839	52,232	4,562	50,954	93,744	652,881

Earthenware, china, brick, and tile imported and entered for consumption in the United States, 1867 to 1897, inclusive.

Year ending—	Brown earthen and common stoneware.	China and porcelain, not decorated.	China and decorated porcelain.	Other earthen, stone, or crockery ware, glazed, etc.	Brick, fire brick, and tile.	Total.
June 30—						
1867........	$48,618	$418,493	$439,824	$4,280,924	....	$5,187,859
1868........	47,208	309,960	403,555	3,244,958	....	4,005,712
1869........	34,260	400,894	555,425	3,468,970	....	4,459,549
1870........	47,457	420,442	530,805	3,461,524	....	4,460,228
1871........	96,695	391,374	571,032	3,573,254	....	4,632,355
1872........	127,346	470,749	814,134	3,896,664	....	5,308,893
1873........	115,253	479,617	867,206	4,289,868	....	5,751,944
1874........	70,544	397,730	676,656	3,686,794	....	4,831,724
1875........	68,501	436,883	654,965	3,280,867	....	4,441,216
1876........	36,744	409,539	718,156	2,948,517	....	4,112,956
1877........	30,403	326,956	668,514	2,746,186	....	3,772,059
1878........	18,714	389,133	657,485	3,031,393	....	3,996,725
1879........	19,868	296,591	813,850	2,914,567	....	4,044,876
1880........	31,504	234,371	1,188,847	3,945,666	....	5,500,388
1881........	27,586	321,259	1,621,112	4,413,369	....	6,383,326
1882........	36,023	316,811	2,075,708	4,438,237	....	6,866,779
1883........	43,864	368,943	2,587,545	5,685,709	....	6,686,061
1884........	50,172	982,499	2,664,231	(*a*)	$666,595	4,363,497
1885........	44,701	823,334	2,834,718	....	963,422	4,666,175
December 31—						
1886........	37,820	865,446	3,350,145	....	951,293	5,204,704
1887........	43,079	967,694	3,888,509	....	1,008,360	5,907,642
1888........	55,558	1,054,854	4,207,598	....	886,314	6,204,324
1889........	48,824	1,148,026	4,580,321	....	788,391	6,565,562
1890........	56,730	974,627	3,562,851	....	563,568	5,157,776
1891........	99,983	1,921,643	6,288,088	....	353,736	8,663,450
1892........	63,003	2,022,814	6,555,172	....	380,520	9,021,509
1893........	57,017	1,732,481	6,248,255	....	338,143	8,375,896
1894........	47,114	1,550,950	5,392,646	....	189,631	7,180,343
1895........	61,424	2,117,425	8,055,473	....	211,473	10,445,795
1896........	41,585	1,511,542	7,729,942	....	247,455	9,530,524
1897........	[b] 32,227	1,406,019	7,057,261	....	146,668	8,642,175

[a] Not separately classified after 1882.

[b] Including Rockingham ware.

THE KAOLINS AND FIRE CLAYS OF EUROPE.

By HEINRICH RIES.

INTRODUCTION.

As is well known, large quantities of kaolins and other high-grade clays are annually exported from Europe to the United States and enter into serious competition with those mined in this country, and, furthermore, the products manufactured from these materials in Europe have competed heavily with the American wares. It therefore becomes a matter of interest and importance to know what the physical and chemical characters of these foreign clays are, so that those American clays already tested can be intelligently compared with them, and that comparisons may be made of specimens to be examined in the future.

Some manufacturers have claimed that the foreign kaolins are superior to the American, but the evidence does not seem to bear out this statement, the truth probably being that foreign ones are used because they can be brought to the market cheaper.

Most of the information concerning European clays and clay products is to be found in the technical journals devoted exclusively to the clay-working industry, and even there the amount of material is not always great. Competition is extremely keen, and the less that is published concerning the raw materials or products the better the manufacturer likes it. From time to time, however, investigations of one or the other well-known clays have been published, some of them the results of detailed studies. The work of Bischof, Seger, and Hecht has added much to our knowledge of the plastic materials of Europe and their technology, and the work of Seger especially commends itself to all those interested in this subject.

The facts presented here are based largely on notes collected by the writer during the summer and winter of 1897, during which time most of the important kaolin and clay deposits were visited, and to them are added such facts of importance concerning the clays as have already been published.

A number of samples of the various well-known European clays have been collected, and the results of tests of them will be given, it is expected, in a future report. A few tests, however, have been completed in time to permit their incorporation in these notes.

Those desiring to obtain information concerning the extent of the clay product industry in Europe, especially in Germany and Austria, are referred to the "Adressbuch der keramischen Industrie," Coburg, 1896, as in these pages it is not possible to go beyond a discussion of the raw materials.

The grades of clay which are of especial interest to Americans are those used in the manufacture of porcelain and white earthenware and in making glass pots and blocks for tank furnaces. But even after the characters of the European clays are known, compared with native ones and found not to be superior, it might still be that the quality of the product in the two instances would show great differences owing to varying methods of treatment. So far as porcelain materials are concerned—viz, kaolin, ball clays, quartz, and feldspar—the United States has supplies of them fully equal to those of Europe, but comparatively little porcelain is manufactured in this country.

PREPARATION OF POTTERY MATERIALS.

All of the foreign kaolins, except those at Coussac-Bonneval, in France, have to be washed before being sent to the market. Sometimes the washing is done at the factory, as in the case of the Royal Porcelain Works in Berlin. At some factories only kaolin, quartz, and feldspar are used in the manufacture of porcelain, but generally a certain amount of plastic clay is added, especially if large objects, such as plates, are to be made. The relative proportions of kaolin, quartz, and feldspar used vary according to the style and grade of the ware and the manner in which it is to be formed. The feldspathic kaolins of Limoges need the addition of quartz, and in some factories a little carbonate of lime is added. The quartz and feldspar are usually calcined first, the red spar of Norway and the cloudy flints from the North Sea both calcining to a white powder. This process also serves to break up the material and prepare it better for grinding.

Rolls of granite or other stone were formerly much used for grinding the quartz and spar, but mills devised by Alsing find almost universal application at the present day, as they are far more economical of power and possess greater capacity. The old stone mills yielded angular, the latter give round grains. The Alsing mill consists of a horizontal sheet-iron cylinder, through which an axle passes. Both the interior of the cylinder and the axle are covered with wood, and over this there is a covering of porcelain about 1¼ inches thick. A mill of medium size is 3 feet long and 4 feet in diameter, and is filled with 350 pounds of rolled flints and the same quantity of charge. About two charges a day can be ground. The kaolins used show a varying rational composition, those of Zettlitz and Cornwall being high in clay substance, while the Prussian and French kaolins often have appreciable amounts of feldspar.

As the foreign manufacturer is usually thoroughly familiar with the rational analysis of his clays, and is able to interpret the character of the material from it, the difference in rational composition between the various kaolins is not a serious matter.

Much attention is paid to the preparation and mixture of the clay, for years of experience have proved this to be a matter of the highest importance. For this purpose all large factories have storage tanks where the mixed clay is piled up and allowed to remain until used, the longer the better. When taken from the storage bins for working into forms it is first thoroughly wedged, to insure the production of the necessary homogeneity in the mass. This operation was formerly done by hand, but in recent years an excellent form of kneading machine has been introduced by Mr. P. Faure, of Limoges. It consists of a circular table about 6 feet in diameter, whose upper surface slopes outward. On this are two conical rolls, 20 to 30 inches in diameter and about 18 inches wide. These rolls have a corrugated rim and are attached to opposite ends of a horizontal axis having a slight vertical play. The clay is laid on the table. and as the rolls travel around on it the clay is spread out into a broad band. A second axle carries two other pairs of rolls of the same shape but smaller size, which travel around in a horizontal plane. These rolls press the band of clay together again. In this way the clay is subjected to successive vertical and lateral pressures, and all air spaces are thoroughly eliminated. The rolls make 10 to 12 revolutions per minute, and a machine kneads two to three charges per hour of 350 pounds each. The introduction of this type of machine into American factories is well worth considering.

The mixtures used for making porcelain vary considerably. The following proportions of materials are given by Hecht:[1]

Composition of mixtures for making hard porcelain.

	Per cent.
Clay substance	40 to 66
Quartz	12 to 40
Feldspar	15 to 30
Carbonate of lime (at times)	6

The variation outside of these limits should be very small, for if the clay substance gets under 40 per cent the refractoriness decreases considerably, as does also the ability of the ware to withstand sudden changes of temperature.

One aim of ceramic chemists has been to produce bodies of low shrinkage, and experiments have indicated that the use of porcelain sherds ground up gives a much more homogeneous mass than can be obtained by the use of quartz.[2]

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[1] Dammer, Chem. Tech., Vol. I, p. 773 et seq.

[2] Chem. Zeit. 1895, p. 89, and Keram. Rundschau, 1895, p. 129.

One mixture of this type is as follows:

Composition of porcelain mixture for the production of bodies of low shrinkage.

	Parts by weight.
Quartz sand	120
Feldspar (Norwegian)	85
Marble	3
Zettlitz kaolin	60 to 70
Porcelain sherds	20 to 60

It has also been found that procelains rich in fluxes are soft, while those poor in these ingredients are hard; neither do the most plastic masses always show the greatest shrinkage. The shrinkage of Seger's porcelain, which is rich in fluxes, occurs mostly in drying, and the total linear shrinkage is 10 per cent; it expands in firing when a certain temperature is reached, owing to the high percentage (45 per cent) of quartz which it contains. Plastic clays give a very smooth surface and are difficult to dry, and are not adapted to the manufacture of large pieces. A mixture poor in fluxes, and with a high shrinkage, can be very lean when it contains no sedimentary clay but kaolin as the plastic element. Bodies of good plasticity, but low in fluxes, are of comparatively recent introduction, and are especially adapted to large objects and chemical stoneware.[1] Owing to its high percentage of clay substance and low fluxes, the mass acquires little translucency when burned at high temperatures, but stands temperature changes very well.

Hecht has recently published the results of some rather detailed investigations on the composition of porcelains and white earthenware bodies poor in lime. It has generally been considered that these two classes of ware varied in composition only between fixed limits, and that the predominance of feldspar in the mixture was generally confined to porcelain. This, however, has proved to be an error, and Hecht finds porcelains which are low in feldspar, and earthenware bodies rich in it. The following examples are given:[2]

Comparative compositions of porcelain and white earthenware.

	Japanese porcelain mixture.	Wegeli porcelain mixture.	Belgian white earthenware mixture.
	Per cent.	*Per cent.*	*Per cent.*
Clay substance	49.44	81.37	58.56
Quartz	45.36	5.53	30.36
Feldspar	5.20	13.10	11.08
Total	100.00	100.00	100.00

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[1] Chem. Zeit. 1894, p. 821.

[2] Thonindustrie Zeit. 1897, No. 21, p. 714.

The conclusions are that the difference between porcelain and white earthenware depends on the temperature at which the material is burned, viz, to vitrification or incipient sintering, and not on the composition.

Some porcelains are vitrified at a temperature of only 2,400° F. (Seger's cone 9.) Examples of this are Seger's porcelain and Copenhagen biscuit ware, whose rational compositions are as follows:

Composition of Seger's porcelain and of Copenhagen biscuit ware, vitrifying at 2,400° F.

	Seger.	Copenhagen.
	Per cent.	*Per cent.*
Clay substance	25	32
Quartz	45	....
Feldspar	30	68

These bodies when burned show a glassy, conchoidal fracture. As the feldspar is that part of the porcelain which brings about the vitrification, we must assume from the Japanese and Wegeli porcelain mixtures, given above, that a much higher temperature is required to sinter them than the Seger and Copenhagen mixtures.

It is possible to find mixtures showing all grades of transition in composition between white earthenware and porcelain.

As to the behavior of easily fusible white earthenware glazes and porcelain glazes on these transitional members, Hecht finds that a great number hold without crazing on bodies having the following composition, whether burned in a hard porcelain fire or moderate white earthenware fire:

Composition of bodies on which many earthenware and porcelain glazes do not craze.

Per cent.		Per cent.
80	Clay substance	30
20	Quartz and feldspar	70

The degree of tenacity with which the glazes hold depends on the temperature at which the biscuit and glazed ware is burned, and to a greater or less extent on the relative amounts of kaolin and plastic stoneware clay in the body.

The practical value of the above observations is that it points toward much greater possibilities in underglaze decoration, for while in the past such work could only be done under hard-fire glazes, we can now paint the porcelain with underglaze colors hitherto used only for white earthenware and cover them with easily fusible muffle glazes.

The effect of excessive grinding on the ingredients of a porcelain mixture has recently been shown to be serious.[1] It was found that if a mixture of kaolin, quartz, and feldspar was ground in a ball mill for 120 hours, the ware in burning became blistered and showed a finely vesicular structure throughout. If, on the other hand, only the quartz and feldspar were ground for 96 hours, and the kaolin then added, the result was a strong, translucent porcelain of normal color and free from blisters. The experiments suggest how porcelains which are only slightly transparent can be made more so.

It is a curious fact that at one or two large German works the old-fashioned potters' kickwheel is still used, but most of the European porcelain factories have machinery operated by steam power. The factories at Limoges, France, and Copenhagen, Denmark, are especially well equipped. Of interest is the form of wheel used for molding oval or elliptical plates and platters. These machines are also manufactured by Mr. P. Faure, at Limoges.

The method of casting is far more extensively used abroad than in the United States, both for porcelain and granite ware, objects with a thickness of one-quarter inch when burned being formed by this method. The process of casting was mentioned in a former report,[2] and need not be described again here. It is usually found that if about 2 per cent by weight of calcined soda is added to the charge, only about one-quarter to one-third the amount of water than would otherwise be necessary is needed to give a slip of the proper consistency. At some works this slip is mixed in a vat and poured into cans for use. At others a pipe leads directly from the vat to the casting table.

The temperatures attained in burning porcelain vary considerably. At Berlin the porcelain is generally burned at a temperature sufficient to melt cone 18 of Seger's series. At Copenhagen cone 26 is used for hard firing. Seger has shown, however, that it is possible to make a porcelain which can be burned at cone 9.

Common stoneware for both ornamental and domestic use is extensively manufactured in Europe, and especially in Germany. Much of it is exported to this country. The higher grades often possess a nearly white body, as the Metlach ware, whose color may be hidden by a slip decoration.

At the present day Vallendar, Bunzlau, and Höhr Grenzhausen are the great centers of the German stoneware industry.

The clays used are very plastic and moderately refractory. Their percentage of ferric oxide varies, so that the clay may burn from a whitish-yellow to a brown. The whitish-yellow clays, of which those from the Westerwald district may be taken as the type, are especially valued. They are free from carbonate of lime, but have an appreciable amount of alkaline silicates. These alkaline fluxes tend to widen the distance between the points of vitrification or clinkering, and viscosity. These clays generally fail or flow at about cone 26.

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[1] Sprechsaal, 1896, No 29, p. 812.

[2] Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. IV, p. 850.

In Germany excellent stoneware clays occur in the Rhine district, in Nassau, along the Elbe River, and others are found in Bohemia.

Numerous analyses are given in the tables further on, but two additional examples of stoneware clays analyzed by Hecht may be quoted here:

Analyses of German stoneware clays.

ULTIMATE ANALYSES.

	1	2
	Per cent.	*Per cent.*
SiO_2	50.42	72.54
Al_2O_3	36.57	20.03
Fe_2O_3	1.30	1.29
CaO	1.57	.54
MgO	.51	.93
K_2O	.49	1.20
H_2O	9.63	4.02
Total	100.49	100.55

RATIONAL ANALYSES.

	1	2
Clay substance	93.41	51.39
Quartz	5.84	47.05
Feldspar	.75	1.16

1. From Vallendar, near Coblentz.
2. From Bendorf, on the Rhine.

A mixture of clays is used in most instances.

The ware is glazed either in burning with salt or when green. Slip glazes are frequently applied, and, as calcareous clays abound, they are generally used. The marly clay from Velten, near Berlin, will serve as a good example of this type (see table of analyses, pp. 88 and 92.) Blast-furnace slag or lead is sometimes added to the glaze clay.

The higher grades of stoneware, especially those which are to be colored, are generally made from white burning clays, with the addition of kaolin. For this purpose the plastic clays of Vallendar, Höhr, Ebernhahn, and Lothain are used. Some of these are so plastic and shrink to such an extent in burning as to require the addition of grog. Sometimes the color is added only to a part of the clay, which is flowed over the surface of the ware. In this case it is important that the slip clay and the body should have the same shrinkage in burning. This is usually brought about by having the two of the same rational composition.

Calcareous clays abound in Europe, especially in northern Prussia, and, aside from their application to brick manufacture, they are abundantly utilized in the production of majolica wares. They usually run high in lime, and sometimes more is added. Red burning clays are often taken, and after having the stones washed out lime and sand are mixed in. The sand serves as a grog and the lime tends to make the body receive the glaze with less danger of cracking. Sometimes marl is used instead of sand and lime. The body generally has more than 25 per cent of carbonate of lime, and may have even 40 per cent.

The majolica and earthenware made from these calcareous clays are usually fired at about 1,700° F., and the glaze is burned on at the same temperature. In burning, both the glazed and unglazed wares are put in the same kiln, but the latter are put nearer to the point of exit of the fire so that the dampness from them shall not pass over the glazed pieces, for it would cause the latter to peel. The burned ware is still soft enough to be scratched slightly with a knife.

GLAZES.

The glazes used for pottery made from calcareous clays are of two kinds, either a frit glaze containing metallic oxides or a fusible clay mixed with lead.

When frit glazes are used they are generally made opaque with oxide of tin. Most of the tin remains in a fine state of suspension instead of going into solution, and therefore an even white color is obtained only by grinding the tin very fine. The mixing of the tin oxide with the unfritted glaze is not good, and such glazes often shrink away in burning and become spotted.

In large potteries a mixture of granulated lead and tin oxide are generally calcined together first, and then mixed with the other ingredients and fritted. The following analyses show the composition of these majolica glazes:

Analyses of majolica glazes.

	1	2	3	4
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	44.96	41.48	51.36	36.49
SnO_2	15.66	23.84	....	1.02
PbO	26.92	23.73	28.84	51.63
Al_2O_3	5.12	4.37	2.12	4.35
Fe_2O_3		.29		.88
Cr_2O_3	....	....	....	.86
As_2O_3	....	....	1.45	....
CuO	.23	....	3.69	1.55
CaO	.51	.66	.52	2.50
Alkalies	6.11	5.87	4.45	2.87
Chlorine	.29	....	....	....
B_2O_3 (by dif.)	....	....	7.57	....

1. Glaze of German stove bricks. Hecht, analyst. Dammer. Chem. Tech., I, p. 773.
2. Feilner's glaze; same ware. Deutsch. Töp. u. Zieg. Zeit., 1872, No. 2.
3. Blue glaze of modern majolica tile; same reference as 1.
4. Dark green glaze; same reference as 1.

The glaze No. 1 is a tin enamel glaze, and shows a composition very close to normal glazes,[1] having the composition—

$$\left.\begin{array}{l}.44\ Na_2O\\ .06\ CaO\\ .50\ PbO\end{array}\right\}\ .21\ Al_2O_3 + 3.2\ SiO_2,\ .44\ SnO_2.$$

Hecht tried to make a frit glaze as follows:

Composition of frit glaze.

	Parts.
Calcined soda	46.99
Chalk	6.07
Lead oxide	113.06
Zettlitz kaolin	52.89
Glass sand	159.87
Tin oxide	64.35

This did not craze on pottery clays with over 20 per cent of calcium carbonate, and burned white at cone 0.09. On the other hand glazes of the type of No. 4 in the preceding table, which was a frit of the formula—

$$\left.\begin{array}{l}.22\ Na_2O\\ .04\ CaO\\ .74\ PbO\end{array}\right\}.19\ Al_2O_3 + 2.09\ SiO_2.$$

had the following composition:

Composition of frit glaze.

	Parts.
Calcined soda	23.64
Marble	4.30
Lead oxide	167.35
Zettlitz kaolin	48.17
Glass sand	103.26

This held only on bodies with 30 to 35 per cent calcium carbonate.

If from the tin glaze No. 1 the tin was omitted, and some of the silica replaced by boracic acid, a colorless glaze was obtained, which held without crazing on bodies having from 20 to 25 per cent calcium carbonate.

The glazes are fritted either in saggars or special furnaces having a basin-shaped bottom.

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[1] Thonindustrie Zeit., 1892, No. 17, p. 153.

In the case of cheap earthenware, a glaze is frequently made from a mixture of clay and fluxes, as mentioned above. Such glazes usually have a formula of—

$$\left.\begin{matrix}0\text{—}.1\ \mathrm{Na_2O}\ (\text{or}\ \mathrm{K_2O})\\ .2\text{—}1\ \mathrm{CaO}\\ .8\ \mathrm{PbO}\end{matrix}\right\}2\ \mathrm{SiO_2}.$$

Sometimes .2 to .3 Al_2O_3 is added. Boracic acid has been tried, but increases the price of the glaze. A glaze of the above formula can be made out of loam, chalk, and lead oxide. It may contain as much as 60 per cent of the latter, the remainder being sand and chalk. Such a glaze is transparent.

Earthenware is generally manufactured from ferruginous clays, which are more infusible than those used for majolica wares. They are frequently covered with a slip glaze of loam and lead oxide, this being poured over the green ware, as the softness of the latter does not permit its being dipped. Glazes of calcareous clays mixed with boracic acid sometimes work well, and are considered better than those of slip clay with lead. The wares are sometimes coated interiorly with a white burning clay, generally mixed with some feldspar, chalk, quartz, and kaolin.

As Germany really leads in the pottery industry as a whole, the preceding notes have been taken largely from that country. There is very close competition, however, between English and German manufacturers of granite ware, but the latter are somewhat in advance.

In the production of structural materials in European countries, Germany also leads. Front bricks and roofing tile are manufactured in enormous quantities, but terra cotta has not yet found the same extensive appreciation in Germany that it has in the United States, although encaustic tiles are produced in considerable amounts. A specially developed branch of this industry has been the execution of mosaic work in clay. Small blocks or cubes from three eighths to three-fourths of an inch on an edge are molded by the dry-press method, a dozen or more at a time, and in many different colors. The blocks are then set together to form a mosaic pattern, each block being chipped beforehand by the workman in order to fit it more closely to the surrounding pieces. The whole is set in cement.

Fire bricks find a much more extended use abroad than in this country, and numerous factories are located in Germany and Austria as well as in England, Denmark, Sweden, and Russia. The production of the latter is being seriously felt by foreign competitors.

There is hardly a district on the continent where clay tile is not used for roofing, and in addition to the factories in Germany and Austria an extremely active center of the roofing-tile industry is located in the vicinity of Marseilles, France. The products from this region come into competition with those of England.

WASHING OF CLAYS.

It frequently happens that a clay as mined is not of the proper quality for immediate use. The trouble may lie in the presence of too much sand, making the clay too lean, or it may contain pebbles of quartz, pyrite, or other materials that are injurious not only on account of their size but also for other reasons, thus necessitating their removal from the clay.

Pebbles and coarse particles can sometimes be removed by means of sieves, but such methods are not always thorough or continuous in their action, and are perhaps chiefly applicable to very plastic clays that are hard to break apart in a washing process.

Most raw materials which are quite unclean can be best purified by washing, which depends on the principle of stirring the clay up in water and allowing the finer particles to pass off in suspension, while the coarser ones remain behind. This system of clay purification is perhaps nowhere more extensively carried on than in Germany, for there are in that country large areas of clays containing great quantities of mechanical impurities, to utilize which means great saving in the cost of manufacture by avoiding the transportation of better clays from distant localities. The region especially referred to is that of northern Germany, which is underlain by beds of calcareous, sandy clays of enormous extent. By a simple washing process the lime pebbles and sand are removed and a most useful material results.

The washing process assumes a variety of forms, depending partly on the nature of the raw clay and partly on the quality of the washed clay which it is desired to obtain. Thus, for instance, the clays to be treated may be fat or lean; they may contain little stones or sand, or big stones and roots, or all of these together.

In most cases it is desired or advisable to get a product which may still have some sand in it. In others the sand itself may be marketable, and then it becomes necessary to get as close a separation of sand and clay as is possible and consistent with economic working.

The probable result is that no one form of machine will serve all purposes, and that the washing apparatus should be differently constructed for different purposes. In Germany the criticism has been made by some that the tendency of the manufacturers of washing machines is to generalize too much, and the chief improvements have been in the line of machinery and arrangements for washing kaolins and other high-grade clays to be used in the manufacture of porcelain.

BASIN WASHING MACHINES.

The machines for washing brick clays and other medium or low grade clays consist in general of a round horizontal basin, open above, and supplied with a stirring apparatus attached to a vertical axis. This stirrer is made up of several rakes set radially on the vertical axis, which stands in the center of the basin and is revolved by steam or horse power. The prongs of the rakes are of iron and are set firmly or with slight play. There is sometimes a smaller supplementary prong hinged onto each of the large ones. The basin is usually of brick or cement, with a depth of 2 to 3 feet and a diameter of 10 to 12 feet.

The clay and water are discharged into this basin, and the stirrer is revolved until the clay is thoroughly loosened or slaked. The sand and pebbles settle to the bottom of the basin, while the action of the stirrers keeps the finer particles of sand and the clay in suspension.

The working of such machines may be either continuous or intermittent. In the former case the slip (water with suspended clay) is allowed to run off continuously, and fresh water and clay are added from time to time. In the latter case the basin is filled with water, a certain amount of clay is put in, and the machine is run until the material is all loosened up, when the slip is drawn off. If the slip is allowed to become quite thick, much fine sand will go off with the clay. The same is apt to occur when a large excess of water is used.

Several forms of basin machines are used in Europe, which differ chiefly in the construction of the stirring apparatus.

One form that was tried unsuccessfully consisted of a system of rolls and rakes. The object of the former was to crush the lumps, but instead of doing so they rolled the clay out into a tough layer on the bottom of the basin, which the rakes had difficulty in breaking up. Another system, that of Jüngst, has the rakes so constructed that they revolve as they travel around the pit. Still another machine, Neuman's, is constructed with a circular channel in the center of the basin, intended to collect the coarse residue in a narrower space.

There are certain objections to these washing machines, which it may be well to mention:

(1) Nearly every one has to be stopped for a certain period to remove the residue. This was formerly done with a shovel, but more recently by means of an endless chain with buckets, or through a door in the floor of the basin. In the most modern machines the endless chain removes the settlings continuously.

(2) A second difficulty is that the water has to do a large part of the work, so that in the case of very plastic, slow-slaking clays the material should be broken up somewhat before being put into the washing machine.

(3) Most of the machines work too slowly, and consequently have a small capacity. The best results are therefore obtained by sufficient velocity of stirrers and continuous removal of slip and residue.

CYLINDRICAL WASHING MACHINES.

A second class of washers are of cylindrical form, with horizontal stirrers. These may be used either for brick clays or kaolins, but their chief application is in connection with the latter. These barrel washers consist of a horizontal cylinder closed at both ends. Within this cylinder there revolves a horizontal shaft bearing iron arms. The water and clay are charged at one end, and the water, with clay and sand in suspension, passes out at the other. In passing through the machine any lumps of clay are broken up, and much coarse sand remains behind in the cylinder. This necessitates stopping the washer from time to time to clean it out. Cylindrical washing machines are generally of limited capacity, but capable of good results if watched. They are used, as at the Royal Porcelain Works, in Berlin, for instance, to give a preliminary cleansing to the raw kaolin before it passes to the troughs.

In such washers it is easily possible to use too much water. If an excess is allowed to pass through the cylinder, much sand passes out with the clay; but in the case of a fat clay, with lime or pyrite pebbles, a large amount of water is desirable to insure their removal. If a lean clay is simply to be made fatter, an excess of water is to be avoided.

The cylinder washer corresponds in principle to the log washer used by kaolin miners in the United States, and, as before mentioned, its chief use is for the preliminary cleansing of pure kaolin.

TROUGHING.

As the material comes from the washing machines it generally passes into troughs. These may serve the purpose of conducting the entire discharge to settling tanks, or may act as a further stage in the process of separation and cleaning. If the slip is carried off in horizontal troughs, these should be of large cross section, and so much sand should settle in them that the material which reaches the settling tanks is totally different from that coming from the machine.

If the washing simply separates sand which is harmless in itself, it is open to several objections, for the disposal of this sandy residue involves expense, it causes additional expense to mix the sand in again, and the slip takes longer to dry than if it were left in the clay. One way is to endeavor to have only material of the desired consistency come from the machine and get this all into the pits. This can be done by having troughs with high, narrow cross section and heavy fall. If this arrangement is not possible, on account of limited space, it may be desirable to elevate the discharged slip to a higher level before allowing it to pass into the troughs.

If, however, the clay and sand are to be thoroughly separated, an excess of water is desirable. For common brick clays it is often best to have 4 or 5 times more water than clay, but for complete separations 30 times the amount may be necessary.[1]

In such cases as the last mentioned, the slip is conducted through long troughs with very little fall, or even in part horizontal. At intervals in these troughs there may be pitlike expansions to catch the sand. Thus, only the finest particles of clay and sand may eventually reach the settling tanks.

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[1] E. Hotop, Thonindustrie Zeit., 1893.

For economy of space the troughing is generally arranged in a zigzag manner, with the various joints parallel.

This method of washing is used at the majority of kaolin-washing plants in Europe and the United States, but certain objections have been urged against it by some. It has been claimed that with such an arrangement we do not get a perfect sorting, and that, instead of continually finer sand being dropped by the decreasing current, little banks of sand will form at corners and along the sides, thereby tending to make the channel narrower and increase the velocity of the current, causing it to carry sand into the settling tanks.

At several localities the plan followed, and one which is said to obviate this difficulty, is as follows: As the slip comes from the washing machine it is discharged into a section of straight troughing, and from this into another of the same depth, but five or six times the width, and divided by as many longitudinal partitions. The water with suspended clay passes from this into a third section, twice as wide as the second and also divided by a number of longitudinal divisions. From here the water and clay pass into the settling tanks.

The advantage of the above arrangement is that the water flows continually in a straight course, but as it is spread out each time over a wider space it flows with an ever-decreasing velocity.

At the kaolin mines in Cornwall, where this plan of troughing is used, there is a board on hinges set across the end of each section. When this is raised the water is backed up somewhat and the velocity of the current is lessened, or if the water is flowing too slowly its speed can be quickened by lowering the board. In the Cornwall district these board sections are known as the micas.

In each successive section the cross-section of the trough is doubled and the velocity of the current becomes only half as great.

SETTLING TANKS.

Next to the troughs come the settling tanks. These are sometimes large and deep, sometimes small and shallow. The former type is mostly used where space is limited.

Small pits have the advantage of permitting the slip to dry more quickly, especially when the layer of sediment is not very thick. A small pit also takes less time to fill and empty, whereas a large pit requires a good while to fill, and a considerable interval is then required for the clay or kaolin to settle. One disadvantage claimed for a number of small pits is that a thoroughly average product is not obtained, owing to the thin layer of settlings and small amount in each; and furthermore, a series of small tanks requires considerable room.

The advantages of big pits are that the clay can be discharged into any one for a considerable period, and if the clay deposit varies in character, the different grades get into the one tank and a better average is thereby obtainable. A large tank, however, requires a much longer time for drying, and can not, therefore, be filled and emptied as many times a season. The number of times which this can be done during the working period depends primarily on the size of the tank, but if it is so constructed as to dry the clay by draining and evaporating off the water, then the location, weather, and soil exert an important influence.

The construction of the settling tank or pit depends on the grade of clay to be washed. For common clays the simplest form of pit is a shallow excavation, or an earth dam thrown up in a level place. The bottom should slope toward the outlet, and if the soil is not sandy a layer of sand is spread over the bottom of the pit. It is sometimes found necessary to set drains in the soil under the tank, but such provisions are not of much use in the case of very fat clays. With lean materials a drainage system works well.

For white-burning clays and kaolins an earth pit is hardly advisable, and the settling tanks are generally made of wood, stone, brick, or cement. At some localities in Germany the tanks are paved with porous bricks. When the kaolins for white earthenware and porcelain are washed in the factory both the troughing and settling tanks are lined with Portland cement.

Drying the kaolin after it has settled may be accomplished in one of two ways:

(1) After the water is drawn off the clay is allowed to remain in the pit, being turned over with a shovel from time to time, and when nearly dry it is removed to racks. This is the cheapest method and one best adapted to low-grade clays, but it is dependent on the weather.

(2) The clay, after settling, is pumped into filter presses and the water is expelled. This is too expensive a method for any except high-grade clays, but in their case it is usually followed.

At Cornwall, England.—The method of washing the kaolin at the mines in Cornwall, England, differs so essentially from those described above that it may be well to mention it in some detail. As mentioned in another portion of this report, the deposits in that region consist of a loose, crumbling mass of kaolinite, feldspar, and quartz. The pits are all open workings, some of them 200 feet in depth. Streams of water are directed down the sides of the pit and wash down the kaolin, which becomes broken up in its descent. At the bottom of the pit the kaolin and water run into long, rectangular stone tanks about 3 feet deep. The quartz quickly settles in these, while the kaolin and mica remain in suspension. As the tank fills up, the water, with the kaolin, runs off through an overflow into a sump, from which it is pumped up through a large pipe to the surface and discharged into the micas. In passing along these the fine sand and mica are removed, and the kaolin which is discharged into the settling tanks has 97 per cent clay substance. These tanks are deep, circular pits of stone, and have no special advantage. The water is drawn off when the material has settled, and the wet kaolin is shoveled through a door into the drying vats, which are long, narrow, shallow tanks with flues underneath for supplying heat from the fires at one end to dry the kaolin. The quartz remaining in the clay pits is loaded into cars from time to time and sent to the surface.

At Rönne, Denmark.—At Rönne, on the island of Bornholm, Denmark, a special plan is also followed, and is described in connection with the kaolin at that locality.

VOGT'S EXPERIMENTS.

Although it is possible by washing to obtain a product which is nearly pure clay substance or kaolinite, at the same time there is a certain percentage of quartz, feldspar, and mica present in the kaolin in such a finely divided condition that the slowest current of water does not cause it to settle. The experiments made by G. Vogt illustrate this point very well.

Mr. Vogt[1] considers that the plasticity which clays have is chiefly due to the hydrated silicate of alumina or kaolinite. Experiments which he made show that the kaolinite is not the only substance which remains in suspension for a long period. For his trials he took quartz from Limousin, orthoclase from Norway, and a potash mica. All three were ground very fine, and then washed in a current of slightly ammoniacal water. The washed materials were then allowed to stand. After twenty-four hours each of the liquids was as opalescent as if it had washed clay in suspension. After nine days the turbidity still remained, but was less marked. At the end of this time the supernatant liquid was ladled off of each and a few drops of hydrochloric acid added to it. The suspended materials coagulated and settled, and the precipitate was collected, dried, and weighed. The mica which had remained in suspension during the nine days was very fine; still the particles glittered in the light. The addition of hydrochloric acid caused the instant settling of the particles, which was also noticed by the cessation of the glittering. The settlings of mica from 1 liter of water amounted to 0.15 gram. This fine-grained mica possessed a plasticity almost equal to that of the kaolin.

From the decanted liquid of the feldspar the hydrochloric acid brought down 0.4 gram of this mineral per liter, while of the quartz only 0.1 gram of sediment was obtained.

A very plastic clay from Dreux was treated in the same manner and after nine days a precipitate of 0.56 gram was brought down.

From these experiments we see that in washing kaolin it is impossible to free it entirely from quartz, feldspar, and mica.

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[1] Thonindustrie Zeit., 1893, p. 140.

If sulphuric acid be added to a mixture of kaolinite, mica, quartz, and feldspar, only the first two are attacked. The clay thus becomes divided into a soluble and insoluble portion. Each will have alkalies, for they are contained in both mica and feldspar. In the soluble portion the alkali is chiefly potash, and when it increases the amount of chemically combined water decreases. If magnesia mica is also present, the ratio of alumina to silica decreases, for magnesia mica has only one-half as much alumina as potash mica.

THE RATIONAL ANALYSIS OF CLAY.

It is a common custom of the manufacturers of porcelain, white earthenware, fire brick, and other refractory goods—in fact of all products made from high grades of clay—to use the rational analysis as a guide in making up their mixtures and keeping them constant. The advantage of this analytical method is that it resolves the clay into its mineral components, and enables us thereby to get an insight into the physical character of the material used, which is frequently a matter of far greater importance than its chemical composition.

The ordinary quantitative or ultimate chemical analysis regards the clay as a mixture of oxides of the elements, although they may be present in entirely different combinations, such as silicates, carbonates or hydrates, sulphates, etc. This condition of combination is of importance, for it may make a vast difference whether a material is present as a silicate or a carbonate.

Silica if present as quartz will decrease the shrinkage and up to certain temperatures increase the refractoriness, but if present in the clay as a component of feldspar it serves the purpose of a flux and somewhat increases the plasticity.

It is not intended, though, that the rational analysis should entirely supplant the ultimate, for this is not possible, as each serves its own purpose.

The ultimate analysis may be used to supply information on the following points:

(1) The purity of the clay, showing the proportions of silica, alumina, combined water, and fluxing impurities.

(2) From the ultimate analysis we can form an estimate of the refractoriness of the clay, for, other things being equal, the greater the total sum of fluxing impurities the more fusible the clay.

(3) The color to which the clay burns may also be judged approximately, for the greater the amount of iron present the deeper red will the clay burn, provided the iron is evenly and finely distributed and an excess of lime is not contained in the clay. If the proportion of iron to lime is as 1 to 3, then a buff product results, provided the clay is heated to incipient fusion or vitrifaction. The above conditions will be affected by a reducing atmosphere in burning or the presence of sulphur in the fire gases.

(4) Clays with a large amount of combined water sometimes exhibit a tendency to crack in burning. This combined water would be shown in the chemical analysis.

(5) A large excess of silica would indicate a sandy clay.

These are practically all the points which the ultimate analysis explains, and they are mostly of a chemical nature.

As regards the rational analysis, it may be carried out in a simple way or an elaborate one.

Most kaolins and other high-grade clays consist only of kaolinite, quartz, and feldspar, the kaolinite forming the finest particles of the mass, while the balance is quartz, feldspar, and perhaps some mica. The finest particles are known as the clay substance, which may be looked upon as having the properties of kaolinite, for the latter is present in it in such a large excess. Now as each of these three components of the kaolin—clay substance, quartz, and feldspar—have characteristic properties, the kaolin will vary in its behavior according as one or the other of these constituents predominates or tends to increase.

As to the characters of these three: Quartz is nearly infusible, nonplastic, has very little shrinkage, and is of low tensile strength; feldspar is easily fusible and of low plasticity by itself; kaolinite is plastic and quite refractory, but shrinks considerably in burning.

Mica may practically be considered as kaolinite, for the reason that there is usually so little of it, and also because the experiments of G. Vogt have indicated that it acts very similarly to kaolin, being, when fine, fairly plastic, and unaffected by a temperature of 1,300° C. In chemical composition it is of course different from kaolinite, but in form it is similar.

If now a kaolin containing clay substance, quartz, and feldspar be treated first with sulphuric acid, the kaolinite is decomposed into sulphate of alumina and hydrous silica. The former is soluble in water, the latter is removed by subsequent treatment with caustic soda, and we have the insoluble residue consisting of quartz and feldspar. In this residue the alumina is determined, and from this the amount of feldspar is calculated, viz:

$$\underset{\text{molec. wt. alumina.}}{102} : \underset{\text{molec. wt. orthoclase.}}{556} : : \underset{\text{weight of alumina.}}{a} : x$$

This is subtracted from the insoluble residue, and the difference is the quartz.

There is still another way of conducting a rational analysis, which is chiefly applicable when the clay contains other minerals besides the kaolinite, feldspar, and quartz, such as carbonate of lime and magnesia, and appreciable amounts of ferric oxide and mica. This second method is Seger's method as elaborated by Langenbeck, and may be illustrated by the following example, a fire clay from Ohio:

Analysis of fire clay from Ohio.

	I. Total analysis.	II. Insoluble in H_2SO_4.
	Per cent.	*Per cent.*
SiO_2	73.21	55.38
Al_2O_3	14.56	2.35
Fe_2O_3	4.79	.39
CaO	.51	.15
MgO	1.07	.05
K_2O	1.75	1.71
Na_2O	1.16	....
Ignition	3.70	....
Total	100.75	60.03

The insoluble residue consists of quartz, feldspar, and perhaps traces of silicate minerals approaching feldspar in composition. In orthoclase (the common feldspar) the amount of silica is about 3.51 times that of alumina. Therefore, the alumina of the insoluble portion multiplied by 3.51 gives the silica of the feldspar, which, subtracted from the total silica of residue, leaves the silica present as quartz. Thus, in the column 2, above, we have:

	Silica.
	Per cent.
$2.35 \times 3.51 =$	8.25
Alumina	2.35
Fluxes	2.20
Per cent feldspar	12.80

Subtracting this from the total insoluble residue gives the amount of quartz.

As the clay substance, mica, and ferric oxide are the soluble portion of the clay, their total composition is obtained by subtracting the insoluble residue (II) from the total analysis, thus obtaining:

	III.
SiO_2	17.83
Al_2O_3	12.21
Fe_2O_3	4.40
CaO	.36
MgO	1.02
K_2O Na_2O	1.20
Ignition	3.70

If we take the average composition of mica (including muscovite and biotite) as: SiO_2, 50 per cent; Al_2O_3, 32 per cent; alkalies, 10 per cent; and other fluxes, 8 per cent, then we have—

	IV.
	Per cent.
1.2 × 3.20 = .	3.84 Al_2O_3.
1.2 × 5 = ...	6.00 SiO_2.
1.2 × 1 = ...	1.20 alkalies.
1.2 × 0.8 = ..	.50 magnesia. .46 iron.

Subtracting Column IV from III gives us clay substance and ferric oxide—

	Per cent.
SiO_2	11.83
Al_2O_3	8.37
Fe_2O_3	3.94
CaO	.36
MgO	.52
Ignition	3.70
Total	28.72

By this operation the clay has been resolved into—

	Per cent.
Quartz	47.23
Feldspar	12.80
Mica	11.84
Ferric oxide	3.94
Clay substance	24.78

Whether it will be of practical advantage to carry out a rational analysis to this extent still remains to be seen. As before stated the work of Vogt has shown that the mica has properties closely similar to kaolinite, so that there will be no real need of separating it from the clay substance. In its simpler form, however, when applied to high-grade clays, the rational analysis has been found to possess great practical value, owing to the fact that if two clays have the same rational composition they will, other things being equal, behave much alike when burned. This fact is made use of by the potter, for example, in the preparation of his porcelain or white earthenware mixture, also by manufacturers of encaustic tiles, fire brick, etc.

To illustrate this point we may take the manufacture of porcelain. Porcelain is made from a mixture of kaolin, quartz, and feldspar. Suppose that we are using for the manufacture of porcelain or fire brick a kaolin which has 67.82 per cent of clay substance, 30.93 of quartz, and 1.25 of feldspar, and that to 100 parts of this is added 50 parts of feldspar. This would give us a mixture of 45.21 per cent of clay substance, 20.62 of quartz, and 34.17 of feldspar.

If now for the clay we had been using we substituted one with 66.33 per cent of clay substance, 15.61 of quartz, and 18.91 of feldspar, and made no other changes, the mixture would then contain 44.22 per cent of clay substance, 10.41 of quartz, and 45.98 of feldspar.

This last mixture shows such an increase in feldspar that it must give much greater shrinkage and fusibility; but, knowing the rational analysis of the new clay, it would be easy by making a simple calculation to ascertain how much quartz or feldspar should be added to bring the mixture back to its normal composition.

EFFECT OF FLUXES IN CLAYS.

Mr. E. Cramer, at the suggestion of the German Firebrick Manufacturers' Association, has recently carried on a series of tests to determine the volatility and effect of fluxes in clay.[1] A very nearly pure clay was taken for the experiments, and first two fluxes were added to it and then three. The results obtained were fairly uniform, but there was always some variation, just as there is a difference between the fusing point of a raw clay and that of grog made from it, the latter being higher.

The composition of the kaolin used by Cramer in his experiments was as follows:

Composition of kaolin in experimenting with fluxes.

	Per cent.
Silica	46.46
Alumina	38.15
Ferric oxide	1.12
Lime	.51
Magnesia	.10
Alkalies	1.06
Ignition	12.82

From this analysis the composition of what the kaolin would be after ignition can be calculated, and is as given in column 1 of the following table, while No. 2 shows its composition after it has been ignited to cone 30:

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[1] Thonindustrie Zeit., 1897, p. 288.

Analyses of clay after ignition.

	1	2
	Per cent.	*Per cent.*
Silica	53.14	53.29
Al_2O_3	43.72	44.47
Fe_2O_3	1.26	1.10
CaO	.56	.43
MgO	.11	.09
Alkalies	1.21	.74
Total	100.00	100.12

No. 2 shows a decrease in Fe_2O_3, CaO, and alkalies.

As the Deville furnace gives a reducing action, Cramer tried mixing the kaolin with carbon made from the coking of sugar. The mixture was heated a number of times to cone 30, and this gave on analysis:

Analysis of a mixture of kaolin and carbon after burning.

	Per cent.
SiO_2	54.06
Al_2O_3	44.58
Fe_2O_3	1.02
CaO	Trace.
MgO	Trace.
Alkalies	.40
Total	100.06

From these experiments Cramer considers that the fluxes are volatile. He considers the greater amount volatilized in the latter case due to the fact that the clay mixture is more porous.

The losses seemed so small that Mr. Cramer endeavored by some means to catch the volatilized materials and get enough of them for analysis. He accordingly put a fire-clay tube through a Deville furnace and in the central portion of the tube placed a piece of kaolin. The ends of the tube were connected with others of glass. After heating the furnace to cone 30, a stream of air was forced in at one end, and at the other there immediately appeared a white cloud in the tube. This white material was collected and on analysis gave (No. 1):

Analyses of volatile portions of fluxes.

	1	2	3
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	59.60	61.10	67.32
Al_2O_3	12.40	11.20	5.98
Fe_2O_3	9.10	11.27	10.98
CaO	1.20	.91	1.21
MgO	7.50	6.41	7.19
Alkalies	9.95	8.92	7.49
Total	99.75	99.81	100.17

No. 2 shows the composition of sublimate when steam instead of plain air was passed through the tube, while No. 3 shows the composition when illuminating gas was used. In the latter case a lot of graphite was deposited, but this was burned off before analyzing the sublimate.

These experiments Cramer considers to be conclusive. He thinks that in long-continued exposure to heat a considerable portion of the fluxes must pass off.

The experiments were repeated with a lump of sand mixed with a little clay. The products of volatilization had 74.2 per cent SiO_2, and 3.8 per cent Al_2O_3.

We have thus obtained a clue to the reason why fluxes did not always give the same result when added to a clay for the purpose of lowering its fusibility. It could furthermore be determined by actual weighing that a mixture of 90 parts by weight of kaolin and 10 parts of calcium nitrate which were burned at 10 lost 0.56 per cent on heating up to cone 30.

A lime and clay mixture was heated 10 times in a porcelain kiln up to cone 17. No. 1 shows its composition before burning and No. 2 after ignition.

Analyses of a mixture of clay and lime before and after burning.

	1	2
	Per cent.	*Per cent.*
SiO_2	48.37	49.00
Al_2O_3	42.67	43.18
Fe_2O_3	.80	.61
CaO	7.27	6.69
MgO	.24	.19
Alkalies	.64	.51
Total	99.99	100.18

A similar mixture of clay and magnesia before burning and after gave:

Analyses of a mixture of clay and magnesia before and after burning.

	1	2
	Per cent.	*Per cent.*
SiO_2	48.39	49.17
Al_2O_3	43.65	43.90
Fe_2O_3	.80	.60
CaO	.35	.32
MgO	6.25	5.61
Alkalies	.60	.56
Total	100.04	100.16

Further experiments showed that most of the loss occurs in the first burning.

As regards the relative effect of the different fluxes on the fusibility, Cramer thinks that they are all the same, when considered in their equivalent amounts. Thus, the kaolin, when replaced by one-fifth its equivalent weight of fluxes, has its fusion point reduced from 35 to between 33 and 34. Expressing these equivalents in percentages, we get—

Equivalent percentages of different clay fluxes.

	Per cent.
K_2O	7.25
FeO	5.55
Na_2O	4.78
CaO	4.32
MgO	3.04

In other words, 4.32 per cent of lime would lower the fusibility as much as 5.55 per cent ferrous oxide.

EUROPEAN CLAYS.

The countries in which high-grade clays and kaolins are mined at the present time are France, Belgium, Germany, Austria, England, Denmark, Sweden, and Russia. Those which supply the American market are Belgium, England, and Germany. The first and third export large quantities of glass-pot clays; the second, much kaolin and ball clay.

The supplies of English kaolin seem almost inexhaustible, but deposits of astonishing extent are rapidly becoming known in Russia, and it is fortunate for Germany that she can draw upon other countries for some of the china clay which she uses. In commerce the term "china clay" is restricted to the English kaolins.

FRANCE.

The porcelain factories at Limoges and that at Sevres have for a number of years drawn part of their kaolin from one of the most remarkable series of clay deposits to be found in Europe. These deposits of kaolin occur to the northwest of the little town of Coussac-Bonneval, south of Limoges, although the locality is given in all books as St. Yrieix. In this region there is found a series of pegmatite veins in gray gneiss, whose width varies from a few inches to about one hundred feet, this being the greatest width noticed. Practically the only foreign mineral associated with the feldspar is quartz, and even this is very rare, so that the decomposition of the former gives rise to a kaolin of snowy whiteness and one which after mining can be sent immediately to the mill without first having to go through a washing process, as it contains no coarse grains.

Two kinds of kaolin are distinguished, viz, "pure kaolin" and "pebbly kaolin," the latter having numerous fine grains of undecomposed feldspar.

At present these kaolin deposits are worked in a most primitive fashion. The material is dug with a pick and shovel and put into small trays, each of which is carried on the head of a woman or boy to the inspection hut, where the pieces are carefully looked over to see that no dirt has adhered to them and then taken to the storage bin, where they remain until shipped.

Although there is evidently an enormous quantity of available material, still the development of these kaolin beds has been retarded for two reasons, viz, that the deposits are owned by a number of different persons whose various properties lie sandwiched in between one another, and also because in mining the pits have to be kept free from water by continual pumping. The water generally has to be conducted off over neighboring property, and this is sometimes not allowed by the adjacent proprietor for fear that his neighbor may gain some slight advantage. Consequently much of the kaolin remains untouched and the only solution of the problem seems to be the formation of a company to buy up the whole tract.

The following analyses indicate the composition of the Coussac-Bonneval kaolin, which is used for manufacturing the highest grades of porcelain ware:

Analyses of Coussac-Bonneval kaolin.

	1	2
	Per cent.	*Per cent.*
SiO_2	47.71	58.39
Al_2O_3	36.78	27.52
Fe_2O_3	....	.36
CaO	....	1.52
MgO	....	.41
Alkalies	2.58	4.29
Ignition	13.03	7.19
Total	100.10	99.68

1. J. Foy, La céramique des constructions, Paris 1883, and Dümler, p. 81.
2. Seg. Ges. Schrift, p. 522.

ENGLAND.

In England kaolin or china clay is mined principally in Cornwall, near the towns of St. Austell and St. Stephens, and also at Tregoning Hill, near Breage. In Devon it is worked at Lee Moor, near Plympton and Cornwood, on the south side of Dartmoor.

The deposits in the vicinity of St. Austell are perhaps the most important, and many of the pits are of gigantic size.

The clay or kaolin results from the decomposition of granite, the decomposed rock generally forming a band of variable width on either side of a tin vein. In former years the veins were worked for the tin they contained, but the kaolinized granite of the walls having also been noticed, Mr. William Cookworthy, about 1750, made experiments with the kaolin in order to test its applicability to the manufacture of porcelain and stoneware. These tests were so successful that the mining of tin was given up and that of kaolin begun, as it was found far more profitable. Since that time the kaolin mining industry has increased enormously, so that the annual shipments from Cornwall amount to about 300,000 tons.

The washed kaolin is used for two purposes, pottery manufacture and paper manufacture. That for the latter purpose is the whitest and finest material obtainable. The kaolin for pottery use is shipped not only to various parts of Great Britain, but also to Germany, France, Belgium, Italy, and Denmark, and to the United States, where it enters into serious competition with the American raw materials. For the manufacture of porcelain it is mixed with feldspar and quartz and perhaps a little plastic clay, but for white earthenware considerable ball clay is added.

The following series of ultimate analyses, taken from various sources, illustrate well the composition of the washed material:

Analyses of washed kaolins from Cornwall, England.

	1	2	3	4	5	6	7	8
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	46.60	46.90	45.38	45.20	48.26	47.47	45.52	46.38
Al_2O_3	39.60	38.35	40.11	37.80	37.64	38.79	40.76	38.60
Fe_2O_3	.10	.09	.02	1.50	.46	.44		
MgO	......	......	.36	......	Trace.	.21	2.17	3.47
CaO	......	......		......	.06	.07	Trace.	Trace.
Alkalies..	.21	1.38	1.17	1 20	1.56	1.14	1.90	1.77
H_2O......	13.03	12.55	12.62	12.50	12.02	11.92	Ign. 9.61	9.08
Total.	99.54	99.27	99.66	98.20	100.00	100.04	99.96	99.30

1-4. From paper by J. H. Collins, The Nature and Origin of Clays. Min. Mag., 1887.

5. H. Hecht, Thonindustrie Zeit., 1891, p. 293. The sample was white, free from grit, and made a lean paste when mixed with water.

6. Ibid., white kaolin, lean, and slaked to paste of little plasticity.

7. Bluebarrow, St. Austell. L. Playfair, analyst. Catalogue to Collection of British Pottery and Porcelain, Museum Prac. Geol., London, 1893.

8. St. Stephens, Cornwall. L. Playfair, analyst. Ibid.

The following three rational analyses show the high percentage of clay substance in the English china clay:

Rational composition of English china clays.

	1	2	3
	Per cent.	*Per cent.*	*Per cent.*
Clay substance	94.25	94.25	97.50
Quartz.....................	.98	1.26	2.50
Feldspar	4.77	4.49	

1 and 2 are the rational analyses of samples 5 and 6 of the preceding table.

3. Made by H. Ries from sample from Royal Porcelain Works in Berlin.

The analyses by Hecht were made in connection with some experiments on the porosity and shrinkage of kaolins, and the following determinations were made on the same samples of which his analyses are given above:

Shrinkage and porosity of china clay at different temperatures.

Temperature.	Porosity.		Shrinkage.	
	1	2	1	2
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Air dried	....	....	2.75	2.67
At cone .09	48.72	49.19	4.17	5.17
At cones 2 and 3	45.51	46.88	7.33	6.50
At cones 7 and 8	38.07	40.54	11.17	11.59
At cone 12	28.63	37.56	13.91	14.00
At cone 18	7.63	7.34	19.33	21.08

There still remains to be known the degree of fineness of the washed kaolin. A sample from the pits of Messrs. Martin Brothers at St. Austell, in Cornwall, was mechanically analyzed by the writer and yielded the following amounts and sizes of particles, 30 grams being taken:

Mechanical analysis of clay from St. Austell.

	Grams.
Clay substance, particles to 0.01 mm. diameter	23.60
Silt, particles up to 0.025 mm	3.21
Very fine sand, particles up to 0.04 mm	2.13
Fine sand, particles from 0.04 to 0.2 mm	.70
Total	29.64

The method employed to wash the kaolin is described under the heading "Methods of washing clays."

BALL CLAYS.

Lying in the neighboring region, in Devon, is an important series of plastic clays which have been derived from the erosion of the neighboring granitic hills. These plastic clays are mined in two separate areas, one 8 miles south of Torrington, the other near Newton Abbot, in Devonshire. This latter, known as the Bovey clay, has been worked for a number of years, and is much used by British potters under the name of Teignmouth clay, because it is shipped from this latter locality.

The following is an analysis of this clay:[1]

Analysis of Teignmouth clay.

	Per cent.
SiO_2	52.06
Al_2O_3	29.38
CaO	.43
FeO	2.37
MgO	.02
K_2O	2.29
H_2O	10.27
Moisture	2.56
Total	99.38

Much clay of a similar nature, known as Poole clay, is mined at Wareham. It is a blue plastic clay of Tertiary age and is extensively used by manufacturers of white earthenware and stoneware. The following analyses indicate its ultimate composition:

Analyses of Poole clay.

	1	2
	Per cent.	*Per cent.*
SiO_2	48.99	59.61
Al_2O_3	32.11	26.81
FeO	2.34	2.03
CaO	.43	.82
MgO	.22	.44
K_2O	3.31	3.57
H_2O	9.63	7.46
Moisture	2.33	....
Total	99.36	100.74

1. Handbook of Pottery and Mus. Prac. Geol., p. 27, 1893.
2. Dümmler. Ziegel-fabrikation, p. 82. No. 2 burns yellowish white.

The beds near Torrington are also of considerable extent, although at times of irregular quality, so that shaft and drift mining have to be resorted to in order to avoid the expense of removing sandy beds which have no value. Both stoneware and ball clays are obtained, and are of a highly plastic, tough nature. The poorer grades are used in the manufacture of fire brick.

Both the Poole and Torrington plastic clays are shipped without washing.

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[1] Percy's Metallurgy, vol. 1, 1875, p. 99.

A sample of the Torrington ball clay was analyzed mechanically, with the following results:

Mechanical analysis of Torrington ball clay.

	Per cent.
Clay substance	86.33
Silt	5.27
Very fine sand	4.70
Fine sand	1.80
Total	98.10

This shows a high percentage of fine particles, several per cent more than washed kaolin. This is quite natural when we consider the grinding which the clay particles must have undergone in being washed down to their present resting place.

Refractory shale clays of Carboniferous age occur near Stourbridge, England, and Glasgow, Scotland. They are generally mined by means of drifts. These refractory clays of Great Britain bear a high reputation, and the crucibles and muffles made from them are well known. The table of analyses following this report indicates their composition.

It is curious to see how far advanced certain branches of the English clay-working industry are as compared with others which show the greatest backwardness.

The manufacture of granite ware and the white earthenware industry has reached a high stage of perfection, especially in Staffordshire; and the Wedgewood, Doulton, and Royal Worcester wares are too well known to need description. They are all characteristic products, but their quality is the result of many years of experiment and not dependent on any peculiarity in the raw materials used.

Much of the plastic clay from Poole and Torrington is used at the Lambeth potteries of Doulton & Co. for the manufacture of stoneware, tiles, and chemical stoneware.

Large quantities of the stoneware are shipped to the United States. It is frequently ornamented in a very tasteful manner by very simple means. The ware is taken when freshly molded, but firm enough to handle. In this condition designs can be impressed on the surface by means of lace, leather, green leaves or other objects. Other designs are incised in the clay by means of a sharp knife. Raised designs are produced by molding the relief decoration in a plaster mold and subsequently fastening it on to the ware by means of slip.

BRICK AND TILE CLAY.

In tiles and enameled brick English manufacturers have been very successful, but face brick of good quality are extremely rare in Great

Britain. The ordinary building brick used in London are porous, underburned products, made from a calcareous loam and molded by hand. A second kind, and one much used in London for fronts, is a large, light-red brick, so soft as to be readily scratched by the knife. These are called "rubbers."

Up to the present time very few dry press brick have been used, as the London architects have regarded them with strong disfavor.

At Peterborough, north of London, is the great center of the pressed-brick industry. The material used is the Fletton shale, a stiff, purplish clay. Many large works are located at this point, and the pits have a depth of 30 to 40 feet. Most of the shale is discharged directly into a dry pan, but some of it is dried first on heated floors or on top of the kilns in order to add to the dry pans when the clay coming from the bank is too moist.

The molding is done in Whittaker and Platt dry-press machines. The brick are burned in a modified form of Hoffmann kiln. Few of those made on the dry-press machines came from the kiln without showing numerous reticulated cracks on the surface, but those made on stiff mud presses are usually free from it. Most of the kilns at Peterborough are so constructed that the greater portion of heat passes directly to the chimney from each chamber, only a small portion reaching the next chamber through openings in the brick partitions. These openings are covered with paper. In the newer kilns erected at Peterborough, however, provision has been made for conducting the heat from the cooling chambers to those not yet burned. With the old arrangement the water smoking of each chamber had to be accomplished by building a temporary fireplace in the bricked-up doorway.

The Staffordshire blue brick, as they are called, are a hard, dense bluish-black brick used sometimes for building, but mostly for pavements, curbs, sewers, walls, and abutments. The clay used at Birmingham, where the greatest quantity of these brick is made, is a very ferruginous shale. The material is first passed through a pair of rolls and then to a circular tempering pan, where, with the addition of water, it is mixed to a thick paste ready for the stiff-mud machine. Some of the brick are re-pressed, and large blocks are molded by hand. The brick are dried on floors heated by flues passing underneath, but the special character of the product is made in the burning. This is done in circular or rectangular kilns which hold 45,000 normal-sized brick. The heat is raised until the brick are on the point of vitrifying. Salt is then thrown into each of the fire holes, so that the brick become covered with a thin glaze. At the same time fresh coal is heaped onto the fires and all openings in the kiln are closed tight. This causes a reduction of the iron in the outer portions of the brick and the thorough fusing together of the particles in this outer crust. On breaking open such a burned brick there is seen the outer bluish-black, thoroughly dense portion from one-half to one inch thick, while within this the body of the brick is still a deep red.

These blue brick have been found to possess enormous strength and toughness and great resistance to weathering; hence their extensive use throughout Great Britain.

FULLER'S EARTH.

Fuller's earth is found at a number of localities in England, but though of wide distribution geographically the individual occurrences are generally of limited extent.

The original use of the English earth was for fulling cloth, and at one time it was considered so valuable for this purpose and sought after so much by foreign as well as English cloth manufacturers that the British Parliament passed a bill prohibiting its exportation. Since then large quantities of the material have been used in the clarification of oils, and for many years the English earth has been the only satisfactory one. The recent discoveries in the United States have, however, made themselves seriously felt in England.

In England the term "fuller's earth" is used, unfortunately, as a stratigraphic as well as an economic term. According to Mr. A. C. G. Cameron, of the British Geological Survey,[1] this name is applied to the marly bed overlying the Inferior Oolite in the south of England. Mr. Cameron states that the true fuller's earth is well developed in the neighborhood of Bath, where it can be traced all around the hills. He adds:

> From the presence in it of bands of blue and yellow clay, which is true fuller's earth, the term originally limited to these varieties has been subsequently applied to the entire formation, and has ever since retained its place in geological nomenclature.
>
> The fuller's earth formation extends from Dorset through East Somerset and Gloucestershire, beyond this it being almost entirely absent. It has not been found, either, in the north of England. Patches of the material have been found here and there in various parts of the country, but the occurrences, owing to their very limited extent, are of no commercial value. For a notice of these minor occurrences reference may be made to Mr. R. S. Woodward's report on the "Geology of England and Wales."

The most important beds of fuller's earth are found in the Lower Greensand formation, and the material has been actively mined on the borders of Bedfordshire and Buckinghamshire. The Lower Greensand formation attains its greatest development in the region around Woburn Sands, and it is here that the fuller's earth mining has been most actively carried on.

Fuller's earth has been found at a number of other localities, as in the marl beds at Raddle pits, near Braithwell, northeast of Rotheram; also at Renton, in Yorkshire; from the chalk deposits at Bepton, in Surrey, and from the Katesgrove kiln, Reading.

The formation carrying fuller's earth near Bath has a thickness of 400 feet. In one pit at Nutfield, near Reigate, in Surrey, the earth has a thickness of 8 to 12 feet, but it generally runs from 4 to 6 feet in thickness. Portions of the beds are generally discolored, owing to the oxidation of the iron.

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[1] Geology, Mining, and Economic Uses of Fuller's Earth: Fed. Inst., Min. Eng., Sept., 1893.

The formation around Woburn Sands is about 220 feet thick, the fuller's earth forming a bed about 12 feet in thickness in the lower half of this. The whole 12 feet, however, can not be used; on the contrary, only about one-half of it is mined. Analyses of this material made by Mr. R. H. Harland gave the following:

Analyses of yellow earth from Woburn Sands.

	Lump.	Powdered.
	Per cent.	*Per cent.*
SiO_2	47.10	47.20
Al_2O_3	16.27	15.66
Fe_2O_3	10.00	10.64
CaO	2.63	2.24
MgO	3.15	2.00
Alkalies		.46
Moisture	15.12	15.44
Ignition	5.73	5.36
Total	100.00	99.00

Analysis of blue earth (undried) from Woburn Sands.

	Per cent.
SiO_2	40.50
Al_2O_3	12.20
Fe_2O_3	6.80
CaO	1.57
MgO	1.00
Alkalies	1.15
Moisture	33.50
Ignition	3.25
Total	99.97

It will be seen that there are two kinds of earth—the blue and the yellow—which do not differ much in chemical composition. For some reason or other the yellow earth is more valuable commercially.

The workings at Woburn Sands are all underground, the earth being reached by a timbered slope about 300 feet long. From the foot of this drifts are run off in different directions, and these also require timbering. The fuller's earth is dug by means of picks and shovels and hauled to the surface in a small car. It goes first to the drying house, which is two stories high and contains sheet-iron shelving on which the earth is spread out. The heat is supplied by flues underneath the lower floor and coal fires at one end. The thoroughly dried earth is fed into a cyclone pulverizer and the powdered material drawn off by means of a powerful fan. A sorting takes place at this stage by the impalpably fine material being carried farther along the off-take flue than that which is not ground so fine. Those portions of the earth not ground fine enough to be carried off by the air current fall back into the pulverizer.

The earth as mined is mostly very fine grained, dense, and homogeneous, but not always with a conchoidal fracture, as in the case of the Bath earth. Streaks of sand occur both in the yellow and blue earth, but they are not extracted, the grains being ground up in the pulverizer.

The colors are not confined to particular layers, but both yellow and blue often occur in the same one, intermixed. This necessitates sorting by hand.

All of the Woburn earth quickly falls to pieces when dropped into water, and exhibits no plasticity.

The product of these mines is probably the best obtained in England, and it is exported on a large scale for use in oil refineries.

Another important plant is located at Midford, near Bath, but the earth mined at this locality is used only for fulling cloth, not having been found suitable for clarifying oils.

The Midford fuller's earth is a compact, dense, hard material, usually of fine grain, gray color, and conchoidal fracture. Pebbles and Jurassic mollusks are common in it.

As it comes from the mines, the material is discharged into a form of wet pan, in which the sides are higher than the rollers, so that the latter can be covered with water. The earth is constantly shoveled into the machine and water is added at the same time. The lumps of earth sink to the bottom and coming under the rollers are thoroughly broken up. The sand remains at the bottom of the pan, but the particles of fuller's earth float around in suspension in the water and pass off with the latter through an outlet at the top of the pan. In doing so the material goes through a 16-mesh screen. The earth and water then flow through earthenware pipes to the works, where they are discharged into pits, passing first over a trough with riffles to catch any remaining sand, and through another screen to separate sticks or leaves. The tanks are of wood and four in number, and after one is filled the earth takes about thirty days to settle. The clear water is then drawn off through a series of openings, closable with pegs, at one end of the tank. The moist earth which has settled in the bottom is then removed to the drying vat. This is about 160 feet long, 8 feet wide, and 1 foot deep. The floor is of porous brick and under it are 9 flues extending from the drying furnace to the chimney. The remaining water is thus driven out by heat and the earth is packed in bags for shipment. Even the washed earth contains an appreciable amount of sand, which can be instantly detected by placing a piece between the teeth. By carrying the washing process on more carefully, however, much of this remaining sand could be removed.

GERMANY.

The high-grade clays of Germany fall into two classes. viz. residual clays, or kaolins, and sedimentary clays.

The kaolins have resulted from the decomposition of igneous rocks, as around Meissen, or from the decay of sandstone, as in Thuringia. The more important German localities are Sennewitz, Dölau, Lettin, and Liebau, near Halle; Saarau in Silesia; Seilitz, Schletta, and Kaschkau, near Meissen; and Eisenberg. There are also many localities in Bavaria.

The sedimentary refractory and semirefractory clays are of vast extent. They are mostly of Tertiary and Carboniferous age, and are frequently associated with beds of coal or lignite. In physical character they are often very dense, fine-grained, and highly plastic. The localities at which such clays are mined can be counted by the dozen, but certain prominent ones may be named and the characters of some of them may be given so far as they have been determined.

In the Rhine province Tertiary plastic clays have been worked in the greatest abundance, their use being for refractory goods, white earthenware, stoneware, porcelain, and encaustic tiles. Important workings occur at Cobern-Condorf and Mühlheim, near Coblenz: also at Heimbach, Weiss, and Urbar, near Vallendar.

In the Hessen-Nassau province the deposits of the Westerwald region are of large extent, the localities of greatest development being Grenzhausen, Höhr, Rorsbach, Ebernhahn, and Siershahn. They are all plastic clays of Tertiary age.

Of greater extent and thickness are the refractory clay beds at Gross-Almerode, where the clay-bearing layers are from 10 to 13 meters thick. The clay is used for crucible manufacture. Epterode, in the same area, also furnishes crucible and pipe clays.

Of equal importance are the plastic materials from the region around Meissen, in Saxony. Among the towns at which these beds are mined are Löthain, Kaschkau, Seilitz, and Mähren, etc. Others occur at Colditz, Zittau, and Waldenburg, in Saxony.

In Silesia the most important localities are Saarau, which furnishes the shale clay, and Buntzlau, producing white plastic refractory clays.

There are numerous localities also in Bavaria and Würtemberg, but their production finds its way mostly to local markets.

The two varieties of clay mined in Germany which are of especial interest to American producers are the glass-pot clays and the kaolins used for making porcelain. The former are exported from Gross-Almerode in large quantities.

KAOLINS.

Germany has no kaolin deposits of such dimensions as the English ones, neither do the native kaolin mines supply the entire demand, for much is also imported from England and Bohemia.

The disintegration and decay of the crystalline rocks around Halle and Meissen has given rise to a number of extensive beds of kaolin of high quality. In the vicinity of Halle kaolin is mined at Lettin, Sennewitz, Dölau, and Liebersdorf, while in the region of Meissen may be mentioned Seilitz and Löthain. The kaolin has resulted from the weathering of the quartz-porphyry of that region and is usually 2 to 5 meters thick, the thickness depending on the depth to which the rock has altered, the kaolin passing gradually into the unaltered rock below. The geologic age of the kaolin is younger than that of the plastic clays which overlie it and older than the drift which covers it in places.

An examination of the porphyries and the kaolins resulting from them was made by E. Reichardt,[1] the samples analyzed being from Muldenstein, between Bitterfeld and Jessnitz, on the Mulde River. The first table below gives the mechanical analysis of (1) porphyry, (2) partially weathered rock, and (3) kaolin, and the second table shows the chemical composition of the rock at these stages in the change.

Mechanical analyses of kaolin found at Muldenstein.

	1	2	3
	Per cent.	*Per cent.*	*Per cent.*
Coarse sand	33.95	22.56	2.48
Fine sand	36.20	37.40	28.52
Finest sand	7.90	12.15	18.42
Clay	9.27	12.26	20.51
Fine clay	7.46	8.55	17.69
Finest floating particles	5.22	7.08	12.38
Total	100.00	100.00	100.00

Chemical analyses of transitional rocks in alteration of porphyry to kaolin.

	1	2	3
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	77.48	75.73	76.48
Al_2O_3	17.10	21.92	21.58
Fe_2O_3	2.83	.98	.97
MnO	.84	.18	.17
CaO	.38	.27	.25
MgO	.10	.10	.07
K_2O	1.03	.55	.16
Na_2O	.13	.08	.01
P_2O_5	Trace.		
Total	99.89	99.81	99.69

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[1] Archiv. d. Pharm., 1874 (3), V, p. 310; Chem. Centralblatt, 1874, p. 694.

The changes, it will be seen, consist of an increase in the alumina and a decrease in the iron, lime, magnesia, and alkalies. The kaolin analysis, however, seems peculiar, as no combined water appears in it and it is not stated that the analysis is of ignited material.

Nearly all of the kaolins around Halle contain an appreciable amount of quartz and feldspar. Those at Sennewitz belong to the Government and are used to supply the Royal Porcelain Works at Berlin, while the neighboring pits supply various porcelain and white-earthenware factories throughout Germany. The poorer grades are used locally or shipped elsewhere for the manufacture of firebrick.

All of the material has first to be washed, and this is done in barrel washers and troughing, in the manner already described.

The following analyses[1] will serve to illustrate the composition of the Halle kaolins, both in the past and present, as their use extends over a period of several years. The analyses are of washed kaolins, No. 1 from Lettin, No. 2 from Kaschkau, and No. 3 from Sennewitz:

Analyses of kaolins from the vicinity of Halle, Germany.

ULTIMATE ANALYSES.

	1	2	3
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	57.08	56.72	64.87
Al_2O_3	29.94	31.07	23.83
Fe_2O_3	.65	.59	.83
MgO	.49	.22	.50
K_2O	2.26	.51	1.39
H_2O	9.87	11.18	8.36
Total	100.29	100.29	99.78
RATIONAL ANALYSES.			
Clay substance	74.09	78.51	63.77
Quartz	17.21	20.90	35.50
Feldspar	8.70	.59	.73
Total	100.00	100.00	100.00
COMPOSITION OF CLAY SUBSTANCE IN THE ABOVE.			
SiO_2	45.63	45.00	45.30
Al_2O_3	38.08	39.32	37.15
Fe_2O_3	.88	.75	1.29
MgO	.66	.28	.78
K_2O	1.84	.53	2.02
H_2O	13.32	14.20	13.11
Total	100.41	100.08	99.65

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[1] From Seger's Notizblatt, 1876. Beitrag zur besseren Kenntniss der Kaoline.

As a further illustration of the character of these kaolins we may quote again from the experiments which the late Dr. Seger made on a series of washed kaolins from Sennewitz:[1]

Experiments on washed kaolin from Sennewitz.

Composition.				Behavior when heated to 960°-1,000° C.		Behavior in hard porcelain fire to cone 18.			Color after burning.
Feldspar.	Quartz.	Clay substance.	Ferric oxide.	Linear shrinkage.	Porosity.	Color.	Linear shrinkage.	Porosity.	
Per ct.	*Per ct.*	*Per ct.*	*Per ct.*						
1.59	33.86	64.55	0.75	.3	31.7	(*a*)	10.2	9.0	Light yellow.
3.24	32.38	64.38	.92	.5	30.0	(*a*)	11.7	2.6	Grayish white.
2.42	31.13	65.50	.93	.5	30.4	(*a*)	12.2	2.2	Do.
5.55	29.36	65.09	.78	.3	31.5	(*a*)	14.2	0	Bluish white.
18.20	32.25	49.55	.95	.2	28.1	(*b*)	12.0	0	Bluish white, vitreous.
1.21	33.39	65.40	.73	.7	31.6	(*a*)	10.1	10.0	Yellowish; earthy fracture.
.54	34.25	65.11	.73	.4	30.2	(*a*)	8.3	12.2	Light yellow.
5.01	36.28	58.73	1.33	.4	28.8	(*a*)	11.8	2.1	Grayish white.
8.64	31.69	59.68	.79	.3	28.8	(*a*)	12.9	0	Do.
8.25	35.15	56.60	.83	.3	28.1	(*a*)	12.0	0	Do.
.98	33.49	65.58	.69	1.0	34.0	(*a*)	6.0	20.9	Yellowish white, earthy.
1.30	31.61	67.09	1.11	.8	30.4	(*a*)	9.9	10.3	Light yellow.
.53	37.44	62.03	.59	.5	31.8	(*c*)	4.3	22.0	Nearly white, earthy.
2.14	36.12	61.74	.63	.4	31.4	(*a*)	11.5	4.1	Yellowish gray.
1.21	38.22	60.57	.51	.3	29.1	(*a*)	11.4	3.3	Do.

a Yellowish white. *b* Reddish white. *c* White.

An examination of the preceding table is rather interesting, as it shows quite a variation in the amount of feldspar contained in the different samples. The quartz shows less variation, and the high amount of it indicates that it must have been in a very fine state of subdivision to have remained in the washed kaolin.

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[1] Seg. Ges. Schrift, p. 531.

Another lot of kaolins, from Halle, gave the following results on analysis:

Analyses of kaolins from near Halle, Germany.

ULTIMATE ANALYSIS.

	1	2	3
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	49.80	53.29	46.94
Al_2O_3	33.70	32.80	37.31
Fe_2O_3	1.00	1.13	1.29
CaO	.94	.31	.35
MgO	Trace.	.20	.23
K_2O	1.33	.72	.65
H_2O	13.15	11.54	13.20
Total	99.92	99.99	99.97

RATIONAL ANALYSIS.

	1	2	3
Clay substance	92.24	87.40	....
Quartz	7.6	11.65	....
Feldspar	.10	.95	....

1 and 2. Washed kaolin from Lettin.
3. Clay substance of No. 2.

The rational analysis of two specimens from Dölau gave the following result:

Rational analyses of clays from Dölau.

	Per cent.	Per cent.
Clay substance	85.67	88.00
Quartz	11.90	8.59
Feldspar	2.43	3.41
Total	100.00	100.00

The kaolins around Halle are generally worked by means of open pits, and the material, which is soft, is easily excavated by means of picks and shovels. The pits vary in depth from 10 feet to 30 or 40, the depth being limited to the distance to which the rock is decomposed.

Overlying the kaolin in places is a plastic Tertiary clay of high refractory quality. This is frequently used to mix with the kaolin in order to give the potter's mixture more plasticity. It is known in the trade as "plastic kaolin."

The kaolins in the region of Meissen, Saxony, have likewise originated from the decomposition of igneous rocks, and their uses are the same as those mined around Halle. Much of the material is used by the Royal Porcelain Factory at Meissen, near Dresden.

The following analyses are taken from various sources:

Analyses of kaolins from near Meissen, Germany.

	1	2	3	4
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Clay substance	38.89	57.46	80.99	81.44
Quartz	54.11	41.11	16.66	14.99
Feldspar	7.00	1.43	2.35	3.57
Total	100.00	100.00	100.00	100.00

1. Raw kaolin, Seilitz.[1]
2. Raw kaolin, Löthain.[1]

3 and 4. Washed kaolin, Seilitz.[2]

The ultimate analysis of No. 3 and the composition of the clay substance are also given herewith.

Analyses of kaolins from Seilitz, near Meissen.

	1	2	3
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	56.15	46.00	56.30
Al_2O_3	32.00	38.82	31.25
Fe_2O_3	.64	.78	.49
CaO	.33	.40	.42
MgO	Trace.	Trace.	Trace.
K_2O	.47	.06	1.10
H_2O	10.81	13.30	10.61
Total	100.40	99.36	100.17

1. Washed kaolin.
2. Clay substance of same.
3. Washed kaolin.

PLASTIC CLAYS.

Of far more importance are the sedimentary plastic clays which occur in this region, those near Löthain especially being very extensively worked. As the beds are frequently of limited extent or covered by a considerable amount of overburden, the clay is usually mined by means of shafts and drifts.

One shaft may pass through several beds, each of which has different qualities and is used for a different purpose; or the same bed may be more sandy in one portion than another, thus necessitating the separation of the two grades, a different use being found for each.

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[1] Seg. Ges. Schrift, p. 892.

[2] Seger, Sprechsaal, 1887, p. 374.

The Meissen region thus supplies clays for stoneware, white earthenware, firebricks, glass pots, sewer pipe, and slip decoration.

Many of the clays mined at Löthain are very plastic and of fair tensile strength. A sample of clay used at the Royal porcelain factory in Berlin for the body of white earthenware showed when air dried a tensile strength of 80 to 110 pounds per square inch. According to a mechanical analysis made by the writer this is composed as follows:

Mechanical analysis of clay from Löthain, Germany.

[H. Ries, analyst.]

	Per cent.
Clay substance	34.00
Dust sand	60.00
Fine sand	6.71
Total	100.71

In mixing it to form a workable mass, 38.40 per cent water was required, and the plasticity was greater than the tensile strength would seem to indicate.

In addition to these tests there are given below a series of analyses taken from various sources:

Analyses of plastic clays from vicinity of Löthain.

	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	K_2O.	H_2O.	Total.	C. S.	Quartz.	Feldspar.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	54.51	31.41	0.68	0.04	0.43	0.55	12.37	99.96	83.04	16.28	.68
2	56.09	30.10	.76	.38	Tr.	.69	12.20	100.24	80.15	19.20	.65
3	59.58	28.68	1.16	.07	Tr.	.54	9.87	99.90	74.28	25.72	Tr.
4	66.05	23.98	.61	.38	Tr.	.14	8.61	100.16	61.03	37.79	1.18
5	58.40	28.88	1.09	.36	Tr.	.31	10.98	100.02	76.25	23.12	.63
6	79.58	13 51	.56	Tr.	.32	.43	5.40	99.80	35.40	62.84	1.74
7	58.77	28.81	.71	.28	.17	.44	11.03	....	76.85	20.69	2.46
8	55.80	19.71	10.27	.48	2.17	6.81	4.40	....	72.39	*a*17.48	11.13
9	55.37	21.03	.70	.15	.25	.38	11.40	....	....	21.08	
10	51.39	35.44	.72	....	.75	.80	11.22	....	89.09	9.92	.99
11	54.66	31.87	.50	....	.88	.89	11.58	....	80.84	19.64	Tr.

a TiO_2, 0.10; SO_3, 0.08.

1 and 2. White earthenware clay. H. Seger, analyst.

3. Glass-pot clay, Rittergut shaft, Löthain. H. Seger, analyst, 1886.

4. Average of 10 white-burning samples from Römer shaft. H. Seger, analyst, 1887.

5. Clay from Erich & Gertrude shaft. H. Seger, analyst, 1888.

6. Clay from Römer shaft. H. Seger, analyst, 1891.

All of the above six are plastic with the exception of No. 6, which, however, is plastic enough for the manufacture of stoneware. At cone 10 the clays burn white, but at cone 18 Nos. 1, 2, and 4 burn slightly yellow, while 3 and 5 become quite dense, with a grayish fracture, but brown color superficially. 1, 2, and 4 are well adapted to furnish the plastic element in porcelain and white earthenware; 6 is adaptable for white earthenware and 3 and 5 for refractory goods. The fusion point of No. 5 is between that of Seger's cones 31 and 32, while that of No. 6 is the same as cone 27.

7. Meissen clay, containing much fine quartz. A very plastic clay, showing strong shrinkage.—E. Adams, Sprechsaal, 1887, p. 496.

8. Colored clay from Meissen. Burns red at cones 2 and 3, but fuses to a black mass at cone 10. Good for slipcoating of stoneware; also for making red brick and terra cotta. On earthenware it burns bright red under the glaze.

9. Clay from Löthain. C. Bischof, Sprechsaal, 1885, p. 323.

10. Kaolin from Löthain-Kaschkau, near Meissen.

11. Kaolin from Kemmlitz, near Meissen.

Both 10 and 11 from H. Seger, Thonindustrie Zeit., 1885, p. 153. In the hardest porcelain fire these two clays remained white and still absorbent. No. 10 was free from cracks, but No. 11 showed great quantities of hair-like ones. No. 10 stood the higher heat of the two.

GROSS-ALMERODE.

The section of Tertiary clays involved at this locality is:

1. Upper, or pipe clay.
2. Crucible clay.
3. Glass-pot clay.

Nos. 2 and 3 are less fat, and form the main deposit. The former is the most important and the most refractory, its properties being such that it will stand great additions of grog and sand to diminish its shrinkage without loss of plasticity. On a fracture it shows a yellow and bluish-white color, waxy look, and fatty feel. It is used for crucibles, and some of the very fat varieties for tailors' colored pencils.

The upper pipe clay is divisible into several grades, viz:

1. Jug or pipe clay; fat, fairly refractory, and takes a salt glaze.
2. Brick clay; impure, brown or yellow, lean, and fusible. Makes an excellent roofing tile.
3. Common pot clay; yellow-white, fat, not very fusible. Used for common cooking utensils.

The composition of the glass-pot clay is as follows:

Analysis of glass-pot clay from Gross-Almerode, Germany.

	Per cent.
SiO_2	43.38
Sand	6.53
Al_2O_3	34.52
Fe_2O_3	1.66
CaO	.76
MgO	.37
K_2O	1.51
SO_3	.26
Ignition	11.04

The best grade of glass-pot clay now being mined is not purified before shipment. It is a clay of great density, plasticity, and fair refractoriness.

An important property is that it burns dense at a comparatively low temperature. This is no doubt due in part to the amount of fine sand and silt which it contains, as indicated by the following mechanical analysis made by the writer of a sample from the Vereinigte Thonwerke at Gross-Almerode:

Mechanical analysis of clay from Gross-Almerode.

[H. Ries, analyst.]

	Per cent.
Clay substance	34.00
Silt	28.60
Fine sand	12.40
Sand	25.66
Total	100.66

An air-dried sample, when mixed with 25.80 per cent of water, gave an extremely plastic, tough paste. The bricklets made from it had an air shrinkage of 5.95 per cent. At cone 0.09 the shrinkage was 11 per cent. It is practically impossible to burn the clay without grog and prevent its cracking.

The glass-pot clay is not a highly refractory one, though, for the writer is informed by Prof. C. Bischof that its fusibility is very little above that of cone 27.

The deposits of Tertiary clays occurring at several localities in the Rhine district are of enormous importance to the clay-working industry. The beds are sometimes as much as 30 meters thick, but not of the same grade from top to bottom. Those around Westerwald have supplied large quantities of clays for the manufacture of stoneware, white earthenware, fire brick, encaustic tiles, etc. The towns at which important pits occur are Bendorf, Bossbach, and Ransbach, all in the Westerwald region.

Analyses are given in the following tables:[1]

Analyses of Westerwald clays.

	1	2	3	4	5
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2 combined	14.17	26.98	60.76	59.51	64.70
SiO_2 free	12.29	53.96			
Al_2O_3	33.75	12.35	27.17	28.45	23.28
Fe_2O_3	.78	....	2.60	1.61	1.35
CaO	.13	.45	1.19	3.65	3.47
MgO	.32	.18			
Alk	2.45	1.42			
H_2O	9.11	*a* 3.58	2.28	1.57	7.20

a Ignition.

1. Best clay in the pits of Neitzert & Co. at Bendorf.
2. Another clay from same pits.
3. Used as a binder for refractory goods, and also calcined before use.
4. Same use as preceding, and in addition is used in the manufacture of glass pots and zinc ovens.
5. Used in the manufacture of stoneware, and also for tiles.

Another locality at which plastic clays, also of Tertiary age, are mined is at Cobern-Condorf, near Coblenz. The clay is 4 to 6 meters thick, overlain by loam, sand, and volcanic tuff to a thickness of 15 to 20 feet.

The following tests of the clay have been made by Prof. C. Bischof, the well-known German ceramic chemist:

Analysis of clay No. 1 from Cobern-Condorf, dried at 120° C.

	Per cent.
SiO_2	69.60
Al_2O_3	19.41
Fe_2O_3	.74
CaO	.65
MgO	.51
K_2O	3.37
Ignition	5.82
Total	100.10

Clay No. 1 is plastic and smooth. At 1,000° C. it burns white, with a linear shrinkage of 4.2 per cent, without warping or tearing. It is used in the manufacture of white earthenware and faience.

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[1] Thonindus. Zeit., 1892, No. 12, p. 245.

Following is an analysis of another clay from the same locality:

Analysis of clay No. 3 from Cobern-Condorf.

	Per cent.
SiO_2	60.40
Al_2O_3	28.23
Fe_2O_3	1.42
CaO	.42
Magnesia	.39
Alkalies	1.98
Ignition	7.80
Total	100.64

Clay No. 3 when heated to 1,100° C. burns grayish white, with occasional black specks, and was still absorbent. The fire shrinkage was 4.5 per cent.

The 60.40 per cent of sand contained 29.70 per cent SiO_2, 0.06 per cent Al_2O_3, and 0.09 per cent K_2O, from which the rational composition figures are:

Rational analysis of clay No. 3 from Cobern-Condorf.

	Per cent.
Clay substance	69.65
Quartz	27.46
Feldspar	2.89
Total	100.00

Hecht[1] gives the following analyses of clays of the Rhine province:

Chemical composition of Rhine province clays.

	1	2	3
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	47.47	....	49.63
Al_2O_3	36.09	....	36.28
Fe_2O_3	2.75	....	1.24
CaO	.20	....	1.57
MgO	.67	....	1.17
Alkalies	1.02	....	.49
Ignition	11.76	....	9.49
Total	99.96	....	99.87
Clay substance	97.89	96.33	93.59
Quartz	1.87	3.24	5.66
Feldspar	.24	.43	.75

1. Mühlheim clay. Dark slate color. Makes very fat paste.
2. Yellow Rhinish clay. Very plastic and dense.
3. Vallendar, gray-yellow clay. Dense and highly plastic. High binding properties. Quartz grains so fine as not to be noticeable.

Shrinkage and porosity of the above clays when burned.

Temperature.	1		2		3	
	Porosity.	Shrinkage.	Porosity.	Shrinkage.	Porosity.	Shrinkage.
Air dried	....	10.58	....	9.75	....	5.34
At cone 0.09	33.49	13.92	33.05	14.25	32.24	10.75
At cones 2 and 3	4.26	21.25	7.19	21.92	1.30	8.75
At cones 7 and 8	2.51	21.75	5.21	22.00	.88	9.17
At cone 12	2.40	21.25	4.39	21.75	.67	8.75
At cone 18	(*a*)	(*b*)	(*a*)	(*b*)	....	15.08

a Vitrified. *b* Unchanged.

The lower shrinkage of the Vallendar clay No. 3, is due probably to the 5 per cent of quartz which it contains. It burns very dense at cone 23, but does not melt until cone 33. These properties, together with its low percentage of iron and high plasticity, make it an excellent binding material in the manufacture of refractory wares.

White plastic clays occur in the vicinity of Strehlen, in Silesia.[2]

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[1] Thonindus Zeit., 1891, p. 293, et seq.

[2] Kosmann, Thonindus Zeit., 1887, p. 62.

The raw kaolin from Tröggendorf showed the following physical composition:

Physical composition of clay from Tröggendorf.

Terms used by Kosmann.	Per cent.
Organic matter	0.04
Clay substance	27.86
Fine silt	5.26
Coarse silt	6.72
Fine mica sand	7.91
Fine quartz sand	11.63
Coarse quartz sand	40.27
Total	99.69

The clay contained 63.48 per cent of insoluble matter and 36.36 per cent of clay substance, the composition of which was as follows:

Composition of clay substance in Tröggendorf kaolin.

	Per cent.
SiO_2	14.42
Al_2O_3	12.10
Fe_2O_3	2.34
CaO	.30
MgO	.29
Alkalies	1.97
H_2O	4.90

The two kinds of clay from Schönbrunn, near Prieborn, were also analyzed, and gave the following results:

Analyses of clay from Schönbrunn.

	White clay.	Gray clay.
	Per cent.	*Per cent.*
SiO_2 (combined)	25.61	27.27
SiO_2 (free)	38.69	35.84
TiO_2		.28
Al_2O_3	23.80	24.52
FeO	1.54	1.07
MnO	.27	.19
CaO	.16	.15
MgO	.54	.51
Na_2O	1.27	1.24
H_2O	8.09	8.12
C		.81
Total	99.97	100.00

A sample of Rühle's pits at Oberjahna, which was tested by the Thonindustrie Zeitung, showed considerable fine sand. It slaked quickly to a formable paste, and burned white. The analysis gave the following:

Analysis of clay from Oberjahna.

	Per cent.
SiO_2	83.78
Al_2O_3	10.75
Fe_2O_3	.55
MgO	.64
Alkalies	.54
Ignition	3.94
Total	100.20
Clay substance	30.55
Quartz	66.61
Feldspar	2.84
Total	100.00

The refractoriness is considered to be low, viz, the same as cone 29, owing to the quartz being very fine and intimately mixed with the clay substance. Owing to undecomposed fragments of mineral matter, it is not applicable in its raw state to the manufacture of stoneware and porcelain. In its washed condition it is available for stoneware, as it is plastic and burns white.

The washing test showed 15 per cent of coarse sand, some of the grains being as large as hazelnuts, and the rational analysis of the washed material gave as follows:

Rational analysis of washed clay from Oberjahna.

	Per cent.
Clay substance	37.48
Quartz	59.61
Feldspar	2.91
Total	100.00

The washed material fuses a trifle easier than the unwashed. It is a good slip or stoneware clay, but owing to its high quartz percentage is not suited for making hard porcelain.

ADOLF'S HÜTTE AND SILESIA.

In addition to the refractory clay mined in the Rhine province and around Gross-Almerode, much is also obtained at Adolf's Hütte, near Bautzen, and in the neighborhood of Saarau, in Silesia.

The mines at the former locality are about 9 miles north of Bautzen, where, underlying lignite, there is a bed of plastic clay and sand 2 to 8 meters thick. Under this latter is a stratum of kaolin.[1]

Analyses of kaolin and clayey sand from Adolf's Hütte.

	Raw kaolin.	Clayey sand.
	Per cent.	*Per cent.*
SiO_2	74.80	82.90
Al_2O_3	20.70	15.20
Fe_2O_3	2.20	1.00
CaO	1.10	.70
MgO	.50	....
Alkalies	.70	.20
Total	100.00	100.00

The very plastic clay has coarse sand grains which have to be washed out before it can be used for refractory washes. When washed, the fusibility of the clay is between cones 35 and 36.

Overlying the lignitic coal is a clay with the following composition:

Analysis of clay from Adolf's Hütte.

	Per cent.
SiO_2	46.61
Al_2O	36.47
Fe_2O_3	2.81
CaO	.14
K_2O	1.44
Ignition	12.80
Total	100.27
Clay substance	96.08
Quartz	1.93
Feldspar	1.99
Total	100.00

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[1] Thonindus. Zeit., 1894, p. 842.

The kaolin is washed in cylindrical machines, with an excess of water, and run out into troughs. The coarser material, which settles near the top of the troughs, has the following composition:

Analysis of coarser materials from clay from Adolf's Hütte.

	Per cent.
SiO_2	57.70
Al_2O_3	40.80
Fe_2O_3	.50
CaO	.40
Alkalies	.60
Total	100.00

The fusibility is at cone 34.

REFRACTORY CLAY.

Saarau.—The Saarau material is a siliceous shale of great refractory properties. It is burned before use, and possesses no plasticity. Its chief use is as grog to mix with plastic fire clays. The analysis of fire clay from Altwasser, in the Saarau district, is given in the table of analyses of German clays.

Neurode.—The refractory shales at Neurode are interbedded with coal seams and red sandstones, and rest on a mass of gabbro, from whose decomposition the clay is supposed to have been derived. The beds are much disturbed, and the fire clay varies in thickness from 0.2 to 20 meters. In appearance this shale is hard, dark blue, and possesses a conchoidal fracture. Nodules of calcite and siderite are common. Certain portions of the beds are, however, quite free from these impurities. Pholerite is very abundant in the main bed.

These Neurode shales have been studied and described at some length by Dr. Fleimann,[1] who quotes the following analyses:

Analyses of refractory shale from Neurode.

	1	2	3	4	5
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	49.85	55.73	51.79	51.09	52.02
Al_2O_3	45.60	42.69	46.53	46.24	45.77
Fe_2O_3	.47	.37	.78	1.08	.98
CaO	1.19	.28	.10	.66	.36
MgO	.77	.23	.15	.21	.30
K_2O	.74	.50	.22	....	.24
Ignition	1.87	.43	.57	.64	.83
Total	100.49	100.23	100.14	99.92	100.50

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[1] Beiträge zur Kenntniss des Gabbrozuges bei Neurode mit spezieller Berücksichtigung der daraus entstandenen feuerfesten Schieferthone. Berlin, 1897.

The product is first calcined in furnaces and then sent to the fire-brick works at Saarau.

Hettenleidelheim.—Still another locality of importance as a producer of refractory clay is Hettenleidelheim, near Grünstadt. The clay is associated with Tertiary limestone and has probably been derived from the neighboring porphyry area of the Donnersberg. The thickness of the refractory clay layer varies from 5 to 10 feet in thickness, and owing to the large amount of overburden and the variable thickness of the clay it is worked by means of a shaft and drifts.

Its use is chiefly for glass pots, but also to a lesser extent for fire brick and crucibles for casting steel.

This clay is used by Prof. C. Bischof as No. 5 of his series of normal clays,[1] and the following analysis is given by him:

Analysis of clay from Hettenleidelheim.

	Per cent.
SiO_2	49.66
Al_2O_3	35.60
Fe_2O_3	1.84
CaO	.51
MgO	.76
K_2O	1.33
Ignition	10.04
Total	99.74

The clay becomes dense at 980° C., and at 1,500° C. begins to show viscosity.

COMPARISON BETWEEN GERMAN AND BELGIAN GLASS-POT CLAYS.

There has been much competition in Europe between the Belgian and German producers of glass-pot clay, and with a view to showing that the German clays are equal if not superior to those of Belgium, Mr. E. Cramer made a somewhat lengthy series of experiments. The results have been recently published in the Thonindustrie Zeitung, 1897, page 47.

In examining a clay to determine its applicability to the manufacture of glass pots or blocks for tank furnaces, the important points to know are: Is the clay refractory enough, and how well does it resist the action of molten glass? European clays suitable for this purpose have been found chiefly in Cretaceous and Tertiary strata. They must be plastic and burn dense. The requirements, therefore, are:

(1) Sufficient refractoriness to withstand the highest heat used without changing form.

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[1] C. Bischof. Die feuerfeste Thone, 1895, p. 175.

(2) Great plasticity, such that 50 to 60 per cent of grog will not produce any appreciable effect.

(3) The clay must burn dense, at as low a temperature as possible.

A clay is refractory enough if its fusion point is the same as cone 30.

In judging of the tensile strength the size of the grog grains must be considered, and the relation in which the different sized grains are mixed, but no fixed rules can be laid down for this last point. Formerly the powder resulting from grinding of grog was thrown away, but now it is added in as it has been found that the binding clay shrinks too much without this, and, as a result, cracks occur between the grains.

A mixture examined showed 100 parts by weight of clay and 120 parts grog. The latter gave no residue with sieve of 10 mesh per square centimeter, 20 per cent remained on 60 mesh, 12 per cent on 120 mesh, 24 per cent on 900 mesh, 30 per cent on 5,000 mesh, and 14 per cent went through.

Clay for glass pots should burn dense at a low temperature, so that when grog is added the temperature will not have to be raised too much to get the required density, for the addition of grog will raise the temperature of this point, and to an extent depending on the amount added. Thus the temperature of densification of the above-mentioned mixture is 5, but that of the clay is 1. If now a clay is used as binding material which sinters at a high temperature, the temperature at which the mixture becomes dense will be so high as to make its burning difficult.

A clay that burned dense at cone 6 reached the same condition only at cone 15 when 50 per cent of grog was added. In using clays of high densifying temperature it may happen that the grog is not burned dense at a temperature at which the glass is to be melted.

The investigation of glass-pot clays, therefore, is restricted to the determination of plasticity, shrinkage, densification temperature, fusion point, and chemical composition. Clays fulfilling all these conditions satisfactorily are rare. They occur on the Rhine, near Vallendar and Mühlheim; in Hessen, near Gross-Almerode and Montabaur; in Bavaria, near Grünstadt, and in the vicinity of Passau and Deggendorf; in Saxony, near Klingenberg; in Silesia, near Saarau.

In Bohemia available clays occur near Pilsen and Melnik; in Austria, near Göltivech and Leoben; in Russia, near Gluchow; in Sweden, at Höganäs, near Helsingborg; in England, at Stourbridge, and at Garnkirk, in Scotland; in France, at Forges les Eaux, and in Belgium, at Andennes.

The following are comparisons of the Belgian and German clays, the latter from the pits of Mr. Carl Borgsmüller in Coblenz. The German (Girode) clays are highly plastic. Numbers I to VI represent different layers in the same pit. Of the Belgian clays, Nos. 1 and 2 (Matagne) are lean. They are, however, sufficiently plastic, and showed no tendency to warp in drying. The fat clay from Belforge Noire acted like the Girode clay, and in drying gave off its water very slowly. The analyses of the clays from the two countries are as follows:

Analyses of Girode and Belgian clays.

GIRODE CLAY.

RAW.

	I.	II.	III.	IV.	V.	VI.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	48.50	46.90	45.65	45.82	44.90	46.90
Al_2O_3	35.10	35.90	38.27	38.38	38.10	36.32
Fe_2O_3	1.80	1.10	1.03	1.02	1.30	1.18
CaO	Undet.					
MgO						
Alkalies						
Ignition	13.06	14.64	14.83	14.92	14.70	13.80
			BURNED.			
SiO_2	55.89	55.06	53.53	53.77	52.72	54.71
Al_2O_3	40.44	42.14	44.85	45.04	44.74	42.37
Fe_2O_3	2.07	1.29	1.17	1.09	1.54	1.37

BELGIAN CLAYS.

RAW.

	Matagne, No. 1.	Matagne, No. 2.	Croix de Pierre.	Belforge Noire.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	73.26	72.50	66.60	42.97
Al_2O_3	18.30	18.54	21.80	34.55
Fe_2O_3	1.04	.84	1.16	1 20
CaO	.75	.55	1.00	1.50
MgO	Trace.	.88	Trace.	.72
Alkalies	.49	.62	.80	.68
Ignition	6.57	6.22	9.00	18.50
Total	100.41	100.15	100.36	100.12
		BURNED.		
SiO_2	78.10	77.29	73.18	52.72
Al_2O_3	19.50	19.76	23.95	42.39
Fe_2O_3	1.10	.90	1.27	1.40

A comparison of the above numbers shows that only the fat Belforge bears any resemblance to the Girode clays. The German clays run lower in iron than the Belgian ones. The other Belgian clays are said to be very sandy.

In the fusion tests I, II, III, and VI failed at cone 34, and IV and V a little below cone 35.

Of the Belgian clays Matagne 1 and 2 fused at cone 28. The Croix de Pierre failed at cone 29; the Belforge Noire at cone 34.

Bricklets were made from the different clays to determine the temperature at which they burned dense. The shrinkage and porosity were then determined. The former is looked upon as a gauge of the plasticity. In determining the porosity the bricklets were heated for one hour in water. The following are the tabulated tests:

Physical tests of Girode and Belgian clays.

GIRODE CLAYS.

AFTER BURNING AT CONE 0.010.						
	I.	II.	III.	IV.	V.	VI.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Shrinkage........	13.00	14.70	12.70	10.70	14.90	12.70
Absorption.......	15.40	15.40	21.70	20.20	19.00	21.70
AT CONE 0.05.						
Shrinkage........	18.80	18.20	19.40	18.70	20.30	19.40
Absorption.......	1.03	1.53	2.10	1.72	3.61	2.10
AT CONE 1.						
Shrinkage........	19.20	18.20	20.30	19.10	20.80	20.30
Absorption.......	1.03	1.53	2.10	1.72	1.72	3.10

The color of the clay when burned to cone 0.05 is yellowish gray. The first four burned dense at cone 0.05, while No. V became dense a little above cone 1.

Physical tests of Girods and Belgian clays—Continued.

BELGIAN CLAYS.

	Matagne, No. 1.	Matagne, No. 2.	Croix de Pierre.	Belforge Noire.
AFTER BURNING TO CONE 0.010.				
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Shrinkage	5	4.2	5.6	14.6
Absorption	13.07	12.30	11.07	6.1
AFTER BURNING TO CONE 0.05.				
Shrinkage	6.90	4.4	6.9	17.2
Absorption	11.40	11.5	9.07	2.9
AFTER BURNING TO CONE 1.				
Shrinkage	7	5.5	7.3	17.3
Absorption	8.3	9.4	5.3	1.2

The only one of these which had burned dense at cone 1 was the Belforge Noire. The others are said not to reach this condition until burned to a much higher temperature.

The Belforge Noire is one of the best Belgian clays, and approaches closely to the celebrated clay of Andennes, whose composition is as follows:

Analysis of Andennes clay.

	Per cent.
SiO_2	49.64
Al_2O_3	34.78
CaO	.68
MgO	.41
Fe_2O_3	1.80
Alkalies	.71
Ignition	12.10
Total	100.12

Glass-pot clay also occurs at Wiesau. It has been investigated in a most thorough manner by Dr. H. Mäckler,[1] and his study of the material is so interesting that the results are quoted here in considerable detail.

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[1] Thonindus. Zeit., 1894, p. 748.

The clay was a very plastic one, and when put through a sieve of 75 meshes per linear inch gave a residue of 80 per cent. This when burned at cone 12 of Seger's series was only partly baked.

The composition of the raw clay was:

Composition of raw glass-pot clay from Wiesau.

	Per cent.
SiO_2	51.33
Al_2O_3	33.69
Fe_2O_3	1.76
CaO	.90
MgO	.52
K_2O	2.20
Loss on ignition	9.67
Total	100.07

Rational analysis of raw glass-pot clay.

	Per cent.
Clay substance	85.20
Quartz	12.56
Feldspar	2.24

The clay substance calculated is as follows:

Clay substance of glass-pot clay from Wiesau.

	Per cent.
SiO_2	43.77
Al_2O_3	39.03
Fe_2O_3	2.07
CaO	1.05
MgO	.61
K_2O	2.13
Loss on ignition	11.34
Total	100.00

This shows the clay substance to have less silica than is required theoretically.

The size of the clay substance and quartz grains is of special importance. Some of the clay was put through a Schöne's separator, and this shows that most of the grains are not over 0.01 millimeter in diameter, thus:

Percentage of different sized grains found in clay substance and quartz after going through a Schöne's separator.

Size of grains.	Per cent.
0.2 mm. and over	0.74
0.05 to 0.2	1.53
0.05	1.16
0.04	1.66
0.03	1.81
0.02	3.74
0.01	89.36
Total	100.00

A rational analysis of the clay substance in the Wiesau clay gave results as follows:

Rational analysis of clay substance in Wiesau clay.

	Per cent.
Clay substance	91.61
Quartz	5.65
Feldspar	2.74
Total	100.00

The plasticity was not tested, as Dr. Mäckler considered none of the methods any good; but it can be stated that to the touch the clay was very fat.

A good indication of the workability of the clay is given by the shrinkage in drying and burning. The test bricks were 60 by 30 by 9 millimeters. In drying the clay shrank strongly, warped and tore, and in burning this was still more noticeable. The amount of water required to give a workable mass was 37.2 per cent by volume.

As the pure clay was difficult to work, grog was added in the form of the same clay, burned at cone 0.05. The grog was ground to pass through a sieve of 12 meshes to the inch, and a mixture of two-thirds raw clay and one-third grog was used. The mass with grog flour was more plastic than that with coarse grog; the former required 35.6 per cent water and the latter 30.2 per cent to make a plastic mass.

The fire tests of the three were as follows:

Fire tests of clay and clay and grog mixture from Wiesau.

Shrinkage temperature.	Raw clay.	Two parts clay and 1 part grog flour.	Two parts clay and 1 part grog sand.
	Per cent.	*Per cent.*	*Per cent.*
In air	6.33	4.33	3.00
To cone 0.09	9.17	5.33	4.17
To cone 0.05	12.83	8.53	6.00
To cone 1	14.33	14.00	9.67
To cone 3	14.66	15.17	14.00
To cone 5	16.16	16.17	14.67
To cone 7	16.16	16.17	13.50
To cone 9	15.17	16.00	13.50

At cone .09 the raw clay burns white; at .05, light yellow; at 1, gray; it then darkens continually until at 9 it is brown.

The shrinkage is less in the case of the mixture, and the bricklets made with fine grog shrank more than those with coarse grog. This was to be expected, partly from the fact that more water was added. The shrinkage up to 0.09 is already large, while the shrinkage of the mixture up to this point was very low. At cone 5 all three have reached the maximum shrinkage. At a higher temperature still, the bricks begin to grow, due to the expansion of the quartz.

Dr. Mäckler has also determined the porosity of the three series of bricklets when burned to different temperatures. This is seen in the following table:

Porosity of bricklets made from the mixtures mentioned in the foregoing table, burned at different temperatures.

Temperature.	Bricklet from raw clay.	Bricklet from 2 parts clay and 1 part grog flour.	Bricklet from 2 parts clay and 1 part grog sand.
	Per cent.	*Per cent.*	*Per cent.*
Air-dried	18.13	26.29	26.22
Burned to cone 0.09	21.21	27.85	28.41
Burned to cone 0.05	8.74	21.41	23.22
Burned to cone 1	0	9.66	14.35
Burned to cone 3	....	6.31	4.76
Burned to cone 5	....	1.61	4.12
Burned to cone 7	....	1.31	4.49
Burned to cone 9	....	.09	4.50

The porosity is larger at 0.09 than when the clay is only air dried, because new cavities have formed, due to the exit of the combined water. The effect of the grog on the porosity is especially noticeable. The natural clay at cone 1 is thoroughly dense, while the one with grog flour shows 19.28 per cent absorption, and with grog sand 27.25 per cent. Going higher in the temperature it is found that the porosity has decreased more rapidly with fine than coarse grog. At cone 5 the flour mixture had 3.45 per cent, while the other had 8.94 per cent. The fusibility as determined in the Deville furnace lay between cones 32 and 33. The clay is, therefore, considered to be of a high grade of refractoriness, but one which sinters easily. It can be used for all purposes where a dense but not white-burning clay is needed. On account of its dense character it is specially suited for objects which come in contact with alkaline fusions or vapors.

The dense nature is understood when we see the high percentage of fine particles shown by the mechanical analysis.

AUSTRIA.

BOHEMIA.

KAOLIN.

Kaolin has been mined for a number of years at Zettlitz, near Carlsbad, in Bohemia. The material has resulted from the alteration of granite, and extends to a considerable depth, some of the workings having gone down nearly 400 feet. As the authorities have recently passed a law forbidding the mining of kaolin to continue below this depth for fear of interfering with the mineral springs, it is highly probable that some of the mines will have to close down.

The kaolin, as it comes from the mine, is coarsely granular, containing grains of undecomposed feldspar and quartz, but subsequent washing eliminates these to such an extent that the washed material usually shows 98 to 99 per cent of clay substance.

The Zettlitz kaolin has a most extended use in Austria and Germany for the manufacture of porcelain and white earthenware. Having a very low percentage of iron, it burns to a very white color.

The best idea of its chemical and physical characters may be gained from the tests tabulated below:

Analyses of washed kaolin from Zettlitz and Sodau, Bohemia.

	1	2	3	4	5
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	40.53	46.87	46.82	45.54	45.72
Sand	5.15	....	....	....	....
Al_2O_3	38.54	38.00	38.49	38.77	39.10
Fe_2O_3	.90	.89	1.09	.61	.42
CaO	.08	Trace.	....	.74	.49
MgO	.38	.35	Trace.	.10	.20
Alkalies	.66	1.22	1.40	.62	.50
Ignition	13.00	12.70	12.86	13.62	13.57
	99.24	100.03	100.66	100.00	100.00
Rational analyses.					
Clay substance	....	98.31	96.55	....	....
Quartz	....	1.05	2.30	....	....
Feldspar	....	.64	1.15	....	....
	....	100.00	100.00	....	....

1. From Zettlitz: Prof. C. Bischof, Die feuerfesten Thone, ed. 1895.
2. From Zettlitz: Dr. H. Hecht, Thonindustrie-Zeit., 1891, p. 293.
3. From Zettlitz: Segers Ges. Schrift., p. 49.
4. From Sodau: Mr. F. Linke, analyst.
5. From Sodau: Prof. C. Bischof, analyst.

These five analyses will serve well to show the high purity of the material.

As regards the fineness of grain, a mechanical analysis of the washed material made by the writer yielded the following results:

Mechanical analysis of washed kaolin from Zettlitz.
[H. Ries, analyst.]

	Per cent.
Clay substance	95.00
Silt	3.50
Very fine sand	1.25
Total	99.75

A rational analysis of this same sample gave—

Rational analysis of the foregoing kaolin.

	Per cent.
Clay substance	98.50
Quartz and feldspar	1.50
Total	100.00

Bricks were then molded from the same material and burned to various degrees of temperature. The shrinkage at these points was as follows.

Shrinkage at different temperatures of bricks burned of Zettlitz kaolin.

Temperature.	Shrinkage.
	Per cent.
In air	3.49
Up to 1770° F	11.14
Up to 2390° F	14.91
Up to 2714° F	17.70

Up to 2,390° F. the clay held its form well, but at 2,714° F. it had warped somewhat and burned very dense, but the fracture was not glassy.

Another set of tests made by Hecht of Zettlitz kaolin gave somewhat greater shrinkage in air and at higher temperatures.

Shrinkages of Zettlitz kaolin determined by Dr. H. Hecht.

Temperature.	Per cent.
In air	6.42
Up to 1,770° F	8.17
2,170° F	3.67
2,350° F	14.25
2,714° F	20.17

The porosity of the clay at these temperatures was:

Porosity of Zettlitz kaolin at different temperatures.

Temperature.	Absorption.
	Per cent.
Air	....
1,770° F	46.25
2,170° F	39.05
2,350° F	36.07
2,714° F	3.02

This indicates a sudden shrinkage and densification between 2,300° F. and 2,714° F.

Professor Seger likewise experimented with this, the standard of European kaolins.[1]

The sample which he used contained the following materials:

Rational analysis of Zettlitz kaolin.

	Per cent.
Clay substance	96.55
Quartz	2.30
Feldspar	1.15
Total	100.00

Its behavior when molded into pyramids and heated to different temperatures was as follows:

At 1,770° F.: Form unchanged; fracture earthy and pulverulent; edges opaque.

At 2,210°-2,570° F.: Form unaltered; fracture earthy, but somewhat harder; edges opaque.

At 2,570°-2,930° F.: Form unchanged; fracture conchoidal and slightly vitreous; edges barely translucent.

Above 2,930° F.: Conditions same as preceding.

At 3,300° F.: Form preserved; fracture glassy; body translucent.

This shows that the kaolin preserves its form at very high temperatures.

The kaolins in the vicinity of Pilsen, also in Bohemia, are similar to the Zettlitz material, but never quite approach it in purity, having more quartz and feldspar. Like the Zettlitz kaolin, they have resulted from the alteration of granitic rocks.

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[1] Ges. Schrift, p. 396.

The composition of kaolins from the vicinity of Pilsen is given in the following table:

Analyses of kaolins from Pilsen.

	1	2	3	4	5
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	59.42	66.76	49.16	49.91	49.48
Al_2O_3	27.15	20.94	36.73	35.99	36.64
Fe_2O_3	1.77	1.92	.81	.63	.66
CaO	....	....	Trace.	....	....
MgO	.52	.81	.18	.30	.41
K_2O	1.50	4.64	1.18	.76	1.60
H_2O	9.85	4.43	12.41	12.34	11.99
Total	100.21	99.50	100.47	99.93	100.78
Rational analyses.					
Clay substance	....	....	86.27	87.41	90.29
Quartz	....	....	5.08	6.40	4.08
Feldspar	....	....	8.65	6.19	5.63
Total	....	....	100.00	100.00	100.00

1. Kottiken, near Pilsen, H. Seger.—Notizbl. des Deutsch. Ver. f. Fabr. u. Ziegeln, etc., 1876, pt. 3.
2. Ledez, near Pilsen: Ibid.
3. Washed kaolin, Ledez, near Pilsen, Seger's Ges. Schr., p. 44.
4. Washed kaolin, Kottiken, Pilsen, Seger's Ges. Schr., p. 44.
5. Washed kaolin, Tremosna, near Pilsen, Seger's Ges. Schr., p. 50.

The pyrometric properties of Nos. 3, 4, and 5 are shown below, being Seger's[1] experiments on these samples.

Pyrometric properties of the last three clays mentioned in the preceding table.

Temperature.	3	4	5
At 1,770° F...........	Form unchanged; fracture earthy and powdery; edges opaque.	Form unchanged; fracture dull; edges opaque.	Form unaltered; fracture dull; edges opaque.
At 2,210–2,570° F.....	Form unchanged; fracture dull; surface somewhat harder; edges opaque.	Form unchanged; fracture dull, hard; edges opaque.	Form the same: fracture dull, edges opaque.
At 2,570–2,930° F.....	Form unchanged; fracture conchoidal: somewhat glassy; edges nearly opaque.	Form unaltered; fracture conchoidal; edges begin to be translucent.	Form unaltered; fracture conchoidal; edges begin to show translucency.
Above 2,930° F.......	Form unaltered; fracture glassy; edges slightly translucent.	Form the same; fracture glassy; slightly translucent.	Form unchanged; fracture glassy; slightly translucent.
Above 3,300° F.......	Fracture shining; edges sharp, but translucent.	Slightly bent; fracture glassy; edges slightly rounded.	Strongly bent; fracture glassy; edges rounded.

REFRACTORY CLAYS.

Refractory clays, and especially shales, occur at several localities in Austria and Bohemia, and some of them have been the subject of detailed chemical and physical investigations.

In the vicinity of Briesen, in northern Austria, is an extensive series of clay beds interbedded with sandstones of Cretaceous age. The areas are those of Briesen proper, Johnsdorf, Korbel-Lhotta, Gross-Oppatowitz, and Pamietitz. The clays are found to be specially adapted to the manufacture of goods of great resistance to high temperature, such as basic refractory bricks, zinc muffles, gas retorts, glass pots, etc. As the tests made by Dr. H. Hecht[2] are of considerable value, but somewhat detailed, it is thought best to give them in tabulated form.

The Briesen clays.—These come from the Ferdinand shaft and Anton shaft, 2 kilometers northwest of Briesen. They are shaly in texture, but slake slowly in water.

Of the clays whose analyses appear in the table given later, prepared by Professor Bischof, Nos. 1, 3, 4, 5, and 6 burned ivory yellow at the melting point of Seger's cone 9, and Nos. 2, 7, 8 showed light gray specks. At the fusion of cone 20, all the clays burned light yellow with gray specks, but vitrification had not taken place.

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[1] Loc. cit.

[2] Thonindustrie Zeit., 1891, p. 461.

Their fusion points or temperatures at which they become viscous range from cone 33 to cone 35.

Analyses of refractory clays from Briesen.

	Ferdinand shaft.			Anton shaft.	
	Back bed.	Front bed.	Shale hang wall.	Front bed.	Outcrop.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	44.37	45.01	46.13	47.46	45.57
TiO_2	....	Trace.	.16	Trace.	Trace.
Al_2O_3	39.76	39.71	36.24	37.58	39.02
Fe_2O_3	1.14	.81	1.28	.98	1.61
CaO	.76	.12	.60	.33	.54
MgO	Trace.	Trace.	.12	.17	.26
K_2O	.67	.99	.83	.90	.54
SO_3	Trace.	....	Trace.	Trace.	.11
Ignition	12.95	13.30	14.68	13.07	12.85
Total	99.65	99.94	100.04	100.49	100.50
			Rational analyses.		
Clay substance	99.07	99.20	93.72	99.36	98.91
Quartz	.32	.41	2.82	.05	....
Feldspar	.61	.39	3.46	.59	1.09

The Briesen clays were furthermore tested by Dr. Hecht with regard to their shrinkage and density at different temperatures, with the following results:

Shrinkage and density of Briesen clays at different temperatures.

Temperature.	Anton shaft, Briesen.		Ferdinand shaft, Briesen.		Black shale, Ferdinand shaft, Briesen.	
	Porosity.	Shrinkage.	Porosity.	Shrinkage.	Porosity.	Shrinkage.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
In air	....	5.25	....	3.67	....	3.75
To cone 0.09	37.04	8.41	34.81	6.41	45.69	8.50
To cone 2 to 3	30.66	11.92	22.19	12.65	33.70	13.58
To cone 7 to 8	24.87	14.00	22.19	12.84	34.62	14.50
To cone 12	19.31	15.92	15.17	15.16	24.81	17.41
To cone 18	1.39	19.75	.75	18.25	1.32	19.75

The Johnsdorfer clays.—These are found 3.5 kilometers northwest of Briesen in the Charlotten and Anna pits. The formation is similar to that at Briesen, but brown coal is also associated with the clay. The latter is dense, shaly, and has a conchoidal fracture. When broken to pea size, both the clays soften quickly in water to a plastic mass. At the fusion point of cone 0.09 they burn light yellow. Their fusion point is about the same as cone 35.

The following table gives analyses of shale and clay from Johnsdorfer:

Analyses of Johnsdorfer shale and clay.

	Shale.	Clay.
	Per cent.	*Per cent.*
SiO_2	47.40	47.06
Al_2O_3	37.06	37.11
Fe_2O_3	1.12	.93
CaO	.40	.18
MgO	.28	.22
K_2O	.87	.11
Ignition	13.40	14.48
Total	100.53	100.09
Rational analyses.		
Clay substance	99.42	99.15
Quartz	.34	.83
Feldspar	.24	.02
Total	100.00	100.00

Korbel-Lhotta, etc.—The Korbel-Lhotta, Gross Oppatowitz, and Pamietitz area lies 4 kilometers south of Briesen. All the clays from here slake rapidly in water. Those from Korbel-Lhotta are fat and plastic.

Analyses of clay from Korbel-Lhotta, Gross Oppatowitz, and Pamietitz.

	Korbel-Lhotta.	Gross Oppatowitz.	Pamietitz.
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	46.82	47.60	50.86
TiO_2	....	.59	....
Al_2O_3	37.54	35.84	33.25
Fe_2O_3	1.17	1.67	.72
CaO	.57	.10	.21
MgO	.21	.39	.72
K_2O	.50	1.14	1.86
Ignition	13.79	13.06	12.44
Total	100.60	100.39	100.06
Rational analyses.			
Clay substance	99.33	92.82	87.38
Quartz	....	.68	11.88
Feldspar	.67	6.50	.74
Total	100.00	100.00	100.00

At cone 0.09 these clays burn light yellow. Their points of viscosity lie between cones 33 and 35 of Seger's series.

Pilsen, Kladno, Rakonitz, and Liebau.—Of considerable interest and importance are certain clay slates which occur at several localities in the Carboniferous of Bohemia and certain parts of Germany. In appearance they are black, siliceous, slaty shales, occurring in beds several inches to several feet thick and full of organic matter.

Before shipment the organic matter is burned out in specially constructed furnaces. The product is a porous, brittle, white mass, of which the purest grades are snow white. This so-called "thonschiefer" of the Germans is very refractory and of low shrinkage, consequently it is much used by many manufacturers of refractory wares to mix with plastic fire clays, serving the same purpose as the American flint clays.

The chief occurrences are in the vicinity of Pilsen, Kladno, Rakonitz, and Liebau. The material is generally hard, dense, homogeneous, and of various shades of gray to blue or black. With water it forms when ground a pasty but not very plastic mass. Pieces of the weathered material, when thrown into water, break or spring apart (especially the fine-grained homogeneous varieties) and then soften and slake to powder. At a low red heat it burns white, but impure samples burn yellow.

Samples of the best grade when tested by Professor Bischof yielded the following results:

At 980° C.: Color of shale, white; body still absorbent; shrinkage, 6 per cent.

At 1,500° C.: Color, white; surface, oily; body absorbent; shrinkage after one heating, 12 per cent; after second, 16.5 per cent. This increased shrinkage on heating twice to 1,500° C. is due to the organic matter not having burned off entirely the first time.

The following are analyses of these shales given by Professor Bischof:[1]

Analyses of Bohemian shales.

	1	2	3	4	5	6	7	8	9	10	11
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
SiO_2........	53.42	49.22	49.55	58.60	55.50	54.47	52.50	57.02	43.15	47.85	53.33
Al_2O_3.......	44.23	33.14	35.19	25.13	41.32	40.89	45.21	40.26	34.63	34.25	33.07
Fe_2O_3.......	.56	.46	.31	2.17	.49	1.18	.81	1.17	1.52	.85	1.43
CaO........	.23	.25	.45	.50	.34	.41	....	.12	.95	.70	.62
MgO........	.23	.14	.31	1.49	.18	.27	.54	.02	.25	.25	.23
K_2O........	.51	.56	1.13	1.70	1.93	1.82	.51	1.36	....	1.26	....
Ignition....	....	15.95	13.70	10.90	.46	.95	.78	....	19.21	14.10	11.18
Total..	99.18	99.72	100.64	100.49	100.22	99.99	100.35	99.95	99.71	99.26	99.86
Sand........	....	8.20	11.50	29.25	....	....	....	....	....	23.95	....

1. Calcined shale (high grade). Altwasser, Walenburger basin. Given for comparison, as it is a German occurrence.
2. Average sample same locality.
3. Wellesweiler. Good quality shale.
4. Duttweiler. Poorer quality shale.
5. Clay slate (calcined), first quality. Engertshaft, Kladno.
6. Clay slate (calcined), second quality. Engertshaft, Kladno.
7. Calcined shale. Rakonitz.
8. Calcined shale. Blattnitz, near Nürschau.
9. Sulkow.
10. Thinfeld, near Kladno.
11. Tremosna.

Tiefenfucha.—Fire clay occurs at Thallern, near Tiefenfucha, interbedded with lignites of Tertiary age. After mining the clay is hand picked, to eliminate any pyrite nodules or gypsum concretions, and is then laid out to weather.

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[1] Oesterreichischen Zeitschrift f. Berg u. Hüttenwesen, XXXVII, 1889.

An analysis of this clay dried at 120° C. gave the following results:[1]

Analysis of Tiefenfucha clay dried at 120° C.

	Per cent.
SiO_2	48.23
Al_2O_3	33.64
Fe_2O_3	1.89
CaO	.05
MgO	.28
K_2O	1.30
SO_3	.158
Ignition	14.63
Total	100.178

At 1,000° C. the clay was found to have a linear shrinkage of 3 per cent, and at 1,500° C. of 9 per cent. At the latter temperature it was still porous.

The clay is very sandy and only of moderate plasticity. Neither are its binding qualities very high, for the average tensile strength of air-dried briquets, as determined by the writer, was 80 pounds per square inch on the average, with a maximum of 105 pounds.

DENMARK.

KAOLIN.

Seventy-five miles southeast of Copenhagen lies the little island of Bornholm, containing the most important clay deposits which Denmark possesses. This small island has an area of not over 11 square miles, but contains a wealth of clay materials which is surprising. The main mass of the island is granite, which is well exposed in the northern half, but on the southern side is covered by extensive beds of Cretaceous and Tertiary clays, sandstones, and marls. On the northern side of Bornholm the granite is extensively quarried for building and paving purposes, but in the southern part, near Rönne, it has been deeply altered to kaolin, and supports an active kaolin and fire-brick industry. There are two large kaolin-washing plants and about ten fire-brick works.

The largest kaolin mines are those belonging to the Dänemark Chamotten Fabrik, whose offices are in Copenhagen. In their pit the kaolin has been excavated to a depth of 70 feet, and it is claimed that borings have proven it to reach a depth of 240 feet. Overlying the kaolin is 4 to 8 feet of glacial drift. The mined material contains an abundance of quartz fragments and unweathered feldspar, and as it comes from the pit is discharged into a cylindrical washing machine with a horizontal revolving framework, which breaks up the material thoroughly. The coarse grains and fragments of undecomposed mineral matter remain in the machine, while the finer particles, consisting of kaolinite, feldspar, quartz, and mica, pass off in suspension with the water which is continually flowing from the machine. This water and suspended material pass along a trough about 50 feet in length, where most of the fine sand is dropped. From this it goes through a stone-lined trough, where still more sand and some mica, of very fine grain, are eliminated.

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[1] From circular of C. v. Popp's fire-brick works; analysis by Prof. C. Bischof.

The material still remaining in suspension is conducted into a circular pit with stone lining. As soon as this pit is full the overflow passes into a second, and so on through six pits. When all six are filled the water is turned into another series of six. By this method of washing the settlings in the last pit are the very finest and should be of high purity. A rational analysis made by the writer of this finest-washed kaolin showed 98 per cent of clay substance.

There is, in addition to the overflow pipe, one leading from the bottom of each pit to the slip pumps.

After the kaolin has settled the clear water is drawn off and the wet kaolin pumped into the filter presses. These have wooden frames and eighteen compartments each. Instead of having an iron supply pipe running along the top of the press with a branch into each compartment there is a hole bored through the upper side of each frame, so that when the press is put together these holes form a continuous tube. Three holes also lead from each of these main ones to the interior part of the frame, thus permitting the slip to reach the compartments and fill the canvas press bags. It requires one and one-half to two hours to fill each press. The washed kaolin is used only for paper manufacture and occasionally for ultramarine. The more sandy quality is sometimes sold to pasteboard makers.

The shrinkage in drying and burning was as determined by the writer as follows:

Shrinkage of Denmark kaolin at different temperatures

	Per cent.
Air shrinkage	5 50
Shrinkage to cone 5	14.00
Shrinkage to cone 9	16.00
Shrinkage to cone 12	20.00
Shrinkage to cone 15	23.80

Up to cone 9 the kaolin burned to a pure white color, but above this it turned grayish, owing to the reduction of the iron to a ferrous condition.

REFRACTORY CLAY.

The more impure portions of the kaolin deposit are used in the manufacture of fire brick. When brought from the mine this second-grade material is first laid out in the sun to dry and then put through rolls to crush the large grains. It is then mixed with ground fire brick and a certain amount of plastic Tertiary fire clay from the company's pits at Hasle, on the island.

This mixture is tempered first in a horizontal and then in a vertical pug mill, after which it is carried to the molding floor. The molding is done entirely by hand, two bricks being formed at a time. They are then re-pressed in a hand-power machine and dried on shelving in the second story of the kiln shed. The burning is done in a continuous kiln.

At the Hasle works of this same company only vitrified, or "clinker" bricks, as they are called abroad, are made.

The Hasle pit presents a variety of clays, and the section given below serves well as an illustration of the sedimentary clay section on Bornholm. Beginning at the top, the beds exposed are as follows:

Section of clay deposit at the Hasle pit, Denmark.

	Feet.
Cross-bedded sand	10
Impure clay	20
Semi-fire clay	25
Black clay (refractory)	4
Clinker clay	15
Fire clay	10

All of the layers are quite sandy and plastic.

CLINKER (VITRIFIED) BRICK.

The clinker bricks are a vitrified product, very much resembling those made at Syracuse, New York. They are largely used for canal work and for pavements. Much care is taken in their manufacture.

The clay is first allowed to soak in a pit for about eight days. It is then put into a vertical pug mill 6 feet long, and as it issues from here it goes to a second one attached to the stiff-mud machine. Three bricks are cut from the issuing bar of clay at a time and removed to a car on which, when a sufficient number have been collected, they are taken to the pallet racks for drying. Burning is done in a continuous kiln. The burned brick are not over 2 inches thick. The first grade, viz, those used for canal work and pavements, are re-pressed after molding, while those for building purposes are not; neither does the clay for the latter go through more than one pugging.

TERRA COTTA.

Another branch of the clay-working industry on Bornholm is the manufacture of terra cotta. Delicate little vases of antique Greek pattern and statuettes, copies of the works of the Danish sculptor Thorwaldsen, have found their way to many markets and are frequently known as Ipsen's terra cotta. At the present day Ipsen's factory is perhaps the largest, but not the only one, turning out this ware.

The materials used are plastic, micaceous, sandy, and at times lignitic clays, which are found on the southern shore of Bornholm Island. By a simple process of washing, the sand and mica are removed, leaving a smooth, plastic material eminently suited for the potter's use. Some of the clays used burn a deep red, others a light buff, and varying shades are often obtained by using a mixture of clays.

The clays are pugged in vertical pug mills and then stored in bins and kept damp until ready for use. Quartz is added to some of the very plastic ones.

Vases and similar hollow forms are generally turned in a plaster mold on the potter's wheel. Tablets, medallions, handles, and similar flat pieces are pressed in plaster molds.

The ware shrinks about one-twelfth in burning, and this operation is conducted in a muffle kiln at a comparatively low temperature.

No glaze is put on the ware; and as it usually receives little or no firing whatever after decorating, it permits the use of many delicate shades of color. Many of the Greek vases are decorated with figures, the outlines of which are put on with a stencil or free-hand, and then filled in with color. The latter work requires little skill and is done by boys or girls.

The products are mostly decorated in a very tasteful manner and have a pleasing form, and the ease with which the ware is manufactured permits it to be sold at a very low figure. Recently much of the statuette work has been done in a white clay in imitation of white bisque ware.

SWEDEN.

The center of Sweden's clay-working industry is the province of Skåne, several mines and factories being located at Höganäs, north of Malmö.

The fire-brick industry of Sweden has become most active in recent years, and exportation is extensively carried on, the product going to German ports along the North Sea, as well as to Russia and Finland.

A number of analyses of burned Swedish fire clays are given by Cronquist[1] as follows:

Analyses of Swedish fire clays (burned).

Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alkalies.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4. Höganüs, common ...	68.70	26.40	1.60	.40	.50	2.40
6. Bjuf, mark "F"	54.20	42.00	1.60	.5	.5	1.2
4. Bjuf, mark "K"	65.60	28.10	2.30	1.1	1.3	1.6
6. Ljungsgard, prima ...	53.90	41.1	1.7	.8	1.6	1.5
6. Stobbarp	60.80	36.1	1.7	.5	.2	.7
3. Billesholm, clay	67.6	25.9	2.6	.8	....	3.1
6. Billesholm, shale.....	51.5	42.9	2.2	1.3	1.2	.5

Refractory clays occur in Sweden, especially in the coal formation of the northwest corner of Skåne. They have been worked in this region since 1827, the localities being Höganäs, Bjuf, Billesholm, Stobbarp, and Ljungsgard—Höganäs being the most important.

According to Dr. Cronquist, there occurs at Bjuf and Ljungsgard a clay slate which is very refractory and possesses good plasticity and which is not equaled by that at Billesholm. Good fire bricks are made at Valläkra with fire clay, and are stamped with the mark "Billesholm;" the common ones are marked "Svaneholm." At Bjuf, "F" and "F^2" are the best bricks and those marked "K" are the common ones.

Two smaller areas of refractory clay occur at Stobbarp and Kramberga. The material at the former locality is very plastic and refractory. The other is less so, but gives a brick of great density and strength. The Kramberga clay is used for clinkers, face brick, and pipes, especially. Many of the Swedish fire clays have TiO_2; the Billesholm shale having 0.8 per cent.

In northeast Skåne kaolin of good quality is found, free from carbonaceous materials and quite plastic.

The gray shales of Bjuf and Ljungsgard, with 16 to 18 per cent of bitumen, require sharp working to develop enough plasticity. The equally refractory shales and clays of Billesholm, with a coal and bitumen percentage of 45 to 60, are not to be made plastic.

Attempts to work the kaolins at Skinnskatteberg and Westmanland have not been successful.

Many of the Swedish fire bricks are said to lack density.

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[1] Teknisk Tidskrift, 1895, pt. 1.

NORWAY.

FELDSPAR.

Most of the feldspar used by European potters is brought from Norway. It is of a bright red color, but burns perfectly white.

The feldspar occurs as veins in gneiss and gabbro. It is best known around Tvedestrand and Arendal, on the southern coast. About 5 kilometers south of the former locality is the Holt pit. This is 2 to 7 meters wide, and the vein runs east and west. It has been dug to a depth of 25 meters, but in most of the mines the spar rarely holds out below 24 meters. The feldspar is quite clear.

The Lambö quarry contains a vein 5 meters wide. It is long, but the material is impure. At the Fjelds quarry the vein is 60 to 70 meters long, 15 to 16 meters wide, and 9 meters deep. It contains plates of mica 2 and 3 meters square, but they are, unfortunately, much cracked.

Other important quarries are in the region of Narresto and Garta, but the largest and most important is at Kalstad, near Kragerö. This latter vein is 17 meters wide, 40 meters long, and has only quartz and feldspar, which are well separated.

At Langö there are 6 large dikes. All of these veins thin out with depth, and the middle portion only of each is of any use. The largest pit is 40 to 50 meters deep, but 20 meters is the average. Veins under 4 to 5 meters thick are not usually worth working. The feldspar is generally blasted out with dynamite.[1]

SCANDINAVIAN CLAY PRODUCTS.

The exposition held at Stockholm, Sweden, during the past year was, no doubt, an agreeable surprise to those interested in clays and clay products, for it demonstrated the activity and progressiveness of the Scandinavian potters and clay workers in general.

Sweden was represented by two large potteries, viz, the Gustafsberg Porcellin Fabrik and Rörstrands Aktiebolag Gesellschaft.

The Rörstrand factory showed a number of porcelain articles with underglaze decoration, resembling somewhat the Royal Copenhagen ware; but those of special interest were vases with metallic-lustered surfaces, chiefly produced by copper.

The Gustafsberg factory had, among others, two interesting types of ware—one made in imitation of blue and white wedgwood, the other after the royal blue of Sevres. They also produce considerable white bisque ware and granite ware.

Refractory wares, including fire brick and retorts, manufactured at Ifö, in southern Sweden, from the kaolins at that locality, were also shown. Analyses of the kaolins are given in tables following. The important center of the Swedish refractory-brick industry is at

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[1] Abs. in Thonind. Zeit., 1894, p. 393, from Norges geologiske undersögelse.

Höganäs, where the fire clays previously mentioned are found. The wares include fire bricks of various shapes, salt-glazed sewer pipe, and stoneware with a lead glaze.

At Iddingen, east of Malmö, a surface clay is used for making red bricks and terra cotta. Both glazed and unglazed examples of the latter were exhibited.

Buff brick and terra cotta are also manufactured in the vicinity of Stockholm.

Of Danish pottery there was an abundant representation at the Stockholm exposition. The Royal Copenhagen Porcelain Factory had a fine series of wares, decorated under the glaze with pale blue and gray colors, the designs being generally figures of animals or plants.

The wares of Messrs. Bing and Gröndal, also of Copenhagen, bear some resemblance to the preceding, but the colors are darker.

There were several exhibits of terra-cotta statuettes and reliefs from Bornholm and Copenhagen, but their characters have been mentioned in another place.

The only objects from Norway were earthenware plates and vases decorated with raised designs of slip clay or coated with a lead glaze.

Russia was represented by a suite of vases from the royal factory in St. Petersburg. They were decorated under the glaze with birds and flowers on a colored ground. Most of them were of large size, and for richness and depth of color they are fully equal to any other European wares.

RUSSIA.

In no European country, probably, has there been such a rapid development of its clay resources as in Russia, and with this development there has been a corresponding increase in clay-working plants.

The most extensive beds of clay have been found in southern Russia, but until recently their value was not known or appreciated.

The porcelain clays are found chiefly in the governments of Kijew, Kherson, and Yekaterinoslav, and in lesser amounts in Tschernigow, Poltava, Charkow, Taurien, and the Don region.

There are 79 localities in Yekaterinoslav, 32 in Kherson, and 54 in Kijew.

All of these clays have been derived from the granitic and gneissic rocks underlying this region.

Semjatschenko makes four classes, viz, nest deposits, layer-like beds, beds, and veins.[1]

The nests are found on the surface of the crystalline rocks in the governments of Kherson and Yekaterinoslav.

The layer-like beds are refractory stoneware clays underlying sandy layers. Most of the South Russian clays fall in this class. Beds of refractory clay occur in departments of Isjum.

South Russian clays. Abstracted in Thonindus. Zeit., 1897, p. 190.

The veins have the purest grades of kaolin, and occur partly in sand or resting directly on the feldspathic rocks.

Semjatschenko has thus far made analyses of clays from 40 of the deposits. The chemical composition of the best South Russian kaolins stands very close to that of ideal kaolin. In the following table is given a list of the alumina and silica percentage in a number of the samples, and for the sake of comparison a number of the best other European occurrences are placed side by side with them:

Silica and alumina content of clays from Russian and other European localities.

Russian localities.	SiO_2.	Al_2O_3.	SiO_2.	Al_2O_3.	Other European localities.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	
Blagodath	45.62	38.96	46.58	38.93	Anglesea.
Wladimirowka	45.83	40.04	45.82	39.42	Rönsdorf (Zwickau), Germany.
Waldheim	44.02	38.58			
Lubimovka	46.61	40.32	46.86	39.97	Seilitz (Meissen), Germany.
Moscharino	47.65	47.02			
Property of Mme. Schelepko	43.80	39.20			
Bjelowodsk	45.68	38.20	45.96	37.97	Zettlitz, Bohemia.
Jelissawetgrad	48.85	37.32	45.68	36.93	St. Irieix, France.
Kresno-Iwanovka	48.41	37.60			
Mürsinji	46.17	37.95			
Gossudarew-Bajerak	47.50	36.30	46.00	37.97	Aue (Schneeberg), Germany.
Pure kaolin	46.50	39.56			

The English china clay has a composition very similar to the kaolins of Blagodath, Wladimirowka, and Lubimowka. It is as follows:

Analysis of English china clay.

	Per cent.
SiO_2	46.32
Al_2O_3	39.74
MgO	.44
CaO	.36
Fe_2O_3	.27
Ignition	14.75

This English clay has hitherto been used in St. Petersburg.

The work of Semjatschenko indicates that kaolinite does not always have the usually accepted formula, and he questions whether plasticity and argillaceous odor really are properties of the hydrated silicate of alumina, and if every hydrated silicate of alumina is a clay. He is tempted to answer in the negative.

The kaolins of Glüchow and Wladimirowka are especially instructive examples.

Analyses of kaolins from Glüchow and Wladimirowka.

	Glüchow.	Wladimirowka.
	Per cent.	*Per cent.*
SiO_2	44.48	45.83
Al_2O_3	38.24	40.04
Fe_2O_3	Trace.	Trace.
CaO	....	.27
MgO	.15	.22
Alkalies and loss	....	.02
H_2O (moist)	3.80	.88
H_2O (chem.)	13.14	13.62
Total	99.81	100.88

Even the external appearance of these two kaolins is said to point to a difference. While the Glüchow kaolin makes a dense mass, which can be rubbed apart with difficulty in an agate mortar, the other has a chalk-like look and rubs off on the finger. The former has conchoidal fracture, while the latter is powdery. The Glüchow clay permits the formation of cylinders of 5 centimeters diameter, and cylinders of 3 centimeters can be bent into an arc of 180°. With the latter clay, cylinders of 12 centimeters can only be bent in an arc of 45°.

The results obtained agree with the amount of water absorbed.

Absorption of water by Glüchow and Wladimirowka clays.

	Glüchow.	Wladimirowka.
	Per cent.	*Per cent.*
Maximum hygroscopic water	14.60	8.25
Volumetric increase	2.90	1.30

The Glüchow clay is made up almost entirely of clay particles; the other clay has only one-third as many.

Some of the refractory clays from the Carboniferous in the vicinity of Borowitschi have been rationally analyzed by Mr. P. Bykow[1] and Mr. Glasenapp, with the following results:

Rational analyses of Russian clays.

	Shdany.	Welgeia.	Mota.
	Per cent.	*Per cent.*	*Per cent.*
Clay substance after ignition	73.11	80.34	74.78
Quartz	14.52	5.97	8.85
Fluxes	12.37	13.69	16.37
Total	100.00	100.00	100.00

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[1] Thonind. Zeit., 1894, p. 265.

The materials are used in the manufacture of refractory wares, and occur in beds from 7 to 3 meters thick. Sandy layers are not uncommon.

The clays were heated up to cone 30 without fusing.

In the coal basin which extends from Tula past Borowitschii and Tichwin to the Onega-See are a number of large and small deposits of fire clay. They are divided into two kinds, known as Suchar and Luin clay. The former is not adaptable to potters' uses, as it always crazes in burning, but it is of excellent quality for the manufacture of refractory wares.

There are four factories at Borowitschii which utilize this material. The first deposit is 4 versts[1] from Borowitschii up the river Msta.

The following tests have been recently made on clay from this region:[2]

Analysis of Borowitschii (Russia) clay.

	Per cent.
SiO_2	43.63
Al_2O_3	40.43
Fe_2O_3	1.03
CaO	.05
MgO	.35
K_2O	.79
Ignition	14.00
Total	100.28

Another deposit occurs on the left shore of the Msta 1 verst from the factory and shows, on analysis, the following composition:

Analysis of Russian clay.

	Per cent.
SiO_2	88.01
Al_2O_3	41.10
Fe_2O_3	1.81
CaO	.24
MgO	.09
K_2O	4.73
Ignition	13.97
Total	99.95
Sand 0.33= 0.13 Al and Fe. 0.05 K_2O. 0.15 SiO_2.	

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[1] 1 verst = 3,500 feet, practically two-thirds of a mile.

[2] Thonindus.-Zeit., 1897, p. 236.

A third deposit 5 versts from factory on the right side of the Msta, on a branch of the Welgeia, gave the following results:

Analysis of Russian clay.

	Per cent.
SiO_2	43.97
Al_2O_3	39.14
Fe_2O_3	1.56
CaO	.18
MgO	.11
Alkalies	.78
Ignition	14.22
Total	99.96

This is a white clay which does not fall apart in water.

Another bed, 8 versts from the factory and 2 versts from the river, showed a composition as follows:

Analysis of Russian clay.

	Per cent.
SiO_2	48.21
Al_2O_3	41.86
Fe_2O_3	2.38
CaO	.73
MgO	.13

There is also used a kaolin from the Donetz coal basin with composition as follows:

Analysis of kaolin from the Donetz coal basin, Russia.

	Per cent.
SiO_2	46.12
Al_2O_3	38.01
MgO	.41
CaO	.23
Fe_2O_3	1.20
K_2O	.71
Ignition	13.55
Total	100.23

Sand 2.23—{0.14 Fe_2O_3 and Al_2O_3.
2.02 SiO_2.

ANALYSES.

A number of analyses have been given in the preceding pages in connection with the descriptions of different deposits, but there are a number of others worthy of record which are given below in tabulated form. The greater number from Germany at once indicates the enormous development of the clay resources of that country.

Table of analyses.

GERMAN CLAYS.

	Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alkalies.	Moisture.	Ignition.	Miscellaneous.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*
1	Puchau	69.25	15.56	5.62	0.45	....	4.16	....	4.97	....
2	Wickendorf near Schwerin.	52.99	13.65	4.60	10.30	2.32	3.60	....	10.52	....
3	Helmstedt	73.20	18.89	4.26	2.87	1.40	1.05	....	6.33	....
4	Schlis, near Borsdorf	46.38+	41.86	1.52	.16	....	.06	.....	7.23	CO_2 .13
5	Altwasser, Prussia	38.94+	36.30	.46	.19	.19	.42	....	17.78	....
6	Reichenau, province of Silesia.	50.46	33.93	3.44	.24	.38	1.02	....	11.00	....
7	Bendorf, Nassau	52.74	33.41	2.20	.94	.61	1.02	....	9.08	....
8	Witterschlick, near Bonn.	52.46	32.56	1.78	....	....	2.38	....	10.61	....
9	Eilenburg, province of Saxony.	34.87+	32.51	2.86	.70	.49	Trace.	....	10.22	....
10	Tschirne, province of Silesia.	56.63	31.50	1.56	Trace.	.14	.34	....	9.98	....
11	Tellendorf, province of Silesia.	55.94	30.99	2.05	Trace.	.61	.97	....	9.51	....
12	Grenzhausen, province of Nassau.	54.44	28.85	2.57	.87	.75	3.39	....	9.13	....
13	Greppin, province of Saxony.	54.99	27.91	2.54	.05	.83	3.67	....	9.87	....
14	Striegau, province of Silesia.	58.29	28.12	1.71	.61	.61	1.85	....	8.87	....
15	Ponoschau, province of Silesia.	57.35	28.19	1.87	.50	1.15	2.40	....	8.57	....
16	.....do	55.85	27.53	2.42	.50	1.19	2.60	....	9.97	....
17	Querfurt, province of Saxony.	59.63	27.58	2.68	1.12	.21	1.86	....	7.04	....
18	Tschirne, Silesia	61.35	26.27	1.12	.10	.52	3.15	....	7.53	....
19	Hainstadt, near Frankfurt am-Main.	60.60	28.15	6.02	....	5.23		....	....	....
20	Helmstedt, Brunswick	50.57	25.46	12.31	....	1.36	1.25	....	9.00	....
21	Neuwied, Rhine province.	56.05	25.05	4.68	.97	1.23	2.46	....	9.10	$\left\{ \begin{array}{c} Mn_2O_3 \\ \text{Trace.} \end{array} \right\}$
22	Siegersdorf, Silesia	60.20	23.87	1.80	.36	1.14	2.85	....	9.83	....
23	Ponoschau, Silesia	57.32	23.84	8.36	.42	.69	1.40	....	7.73	CO_2 .25

Table of analyses.

GERMAN CLAYS.

Clay subs.	Quartz.	Feldspar.	Reference.	Uses.	Remarks.	
Per ct.	*Per ct*	*Per ct.*				
....	....	....	Seger, Ges. Schrift., p. 868.	Used for bricks; takes a brown glaze.	Loamy clay............	1
....	....	....	Ibid., p. 869	Brick clay; washed clay.	With reducing flame burns yellow at cone 0.05.	2
....	....	....	.....do	Brick clay; takes glaze; made of clay, with mixture of ferric oxide and lead oxide.	Burns dark red at cone 0.05.	3
....	2.44		Dümmler, Zieg.-Fabr'n, p. 80 (G. Heppe, anal.).	Front brick.......	Burns yellow..........	4
....	4.90		C. Bischof, Die feuerfesten Thone, 1895.	Fire clay..........	Fusibility at cone 36—.	5
....	....	....	Deutscher Zieg.-Kalender, 1896.	Fire clay; refractory wares.	Burns yellow	6
....	....	....	Dümmler, Zieg.-Fabr'n, p. 80.	Fire clay...........	.....do	7
....	....	....	C. Bischof	.....do	Burns gray............	8
....	18.54		Dümmler, Zieg.-Fabr'n, p. 80.	.....do	....	9
....	....	....	Deutscher Zieg.-Kalender, 1896.	.....do	Burns white...........	10
....	....	....	.....do	.....do	.....do	11
....	....	....	Dümmler, Zieg.-Fabr'n. p. 82.	.....do	....	12
79.42	14.30	6.28	Seger, Ges. Schrift., p. 46.	Front brick.......	Burns yellow..........	13
....	....	....	Dümmler, Zieg.-Fabr'n, p. 82 (H. Liedtke, anal.).	....	....	14
....	....	....	.....do		Burns light yellow	15
....	....	....	.....do	....	....	16
....	....	....	....do	....	Burns light yellow	17
....	....	....	Carl Bischof............	....	Fusibility at cone 26—	18
....	....	....	Dümmler, Zieg.-Fabr'n, p. 82 (Dr. Petersen, anal.).	Front brick.......	Burns yellow; ferric oxide occurs as grains in clay and not in a fine state of division.	19
....	....	....	Ibid., p. 82	.....do	Burns red..............	20
....	....	....	Seger, Ges. Schrift., p. 89	....	Burns yellowish brown.	21
....	....	....	Dümmler, Zieg.-Fabr'n, p. 82	Front brick.......	Burns yellow..........	22
....	....	....	.....do	....	Burns red..............	23

Table of analyses—Continued.

GERMAN CLAYS—Continued.

	Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alkalies.	Moisture.	Ignition.	Miscellaneous.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*
24	Gerdauen, East Prussia	55.41	23.11	7.00	1 28	2.37	3.10	....	7.62	Mn_2O_3 .16
25	Ullersdorf, near Naumburg, am Quaiss.	24.66 *a*	22.50	1.75	.66	.67	1.34	....	7.44	....
26	Ulm, Wurtemburg	56.33	22.37	7.64	1.46	1.86	2.22	....	8.10	....
27	Eschweiler, Rhenish Prussia.	54.83	21.51	9.21	.73	2.17	1.69	....	9.86	....
28	Thansau, Bavaria	58.53	21.90	6.26	1.33	2.24	3.35	....	6.44	....
29	Senftenberg, province of Brandenburg.	62.70	21.30	3.06	.58	.53	2.99	....	8.57	....
30	Neuwied, Rhine province.	64.37	21.91	3.04	.70	1.37	2.99	....	4.71	....
31	Bielefeld, Westphalia	44.78	19.59	5.81	10.80	1.47	2.11	....	6.85	CO_2 8.59
32	Ottersweiler, Baden	59.01	20.70	5.51	.52	1.26	3.15	....	9.89	....
33	Tschirne, Silesia	68.83	21.30	1.13	.35	.40	.75	....	7 27	....
34	Siegersdorf, Silesia	66.13	21.05	2.40	.17	.82	3.10	....	6.34	Mn_2O_3 Trace.
35	Witterschlick, near Bonn.	69.20	20.70	1.06	.27	.20	2.30	....	6.27	....
36	Würzburg, Bavaria	64.43	21.08	4.23	....	2.98	2.71	....	4.64	....
37	General Blumenthal Mines, Westphalia.	57.58	19.76	8.99	.79	2.08	1.39	....	9.51	....
38	Rathenow	61.30	18.87	6.66	.85	1.20	3.20	....	8.28	....
39	Lindenerberg, Hannover	59.91	17.96	1.09	8.21	.40	.41	....	5.64	CO_2 6.02 SO_3 .46
40	Gerdauen, East Prussia	64.62	18.74	4.76	1.32	1.77	3.00	....	5.82	Mn_2O_3 Trace.
41	Uellnitz, Saxony	50.21	17.15	7.58	5.13	6.94	1.37	....	5.76	CO_3 5.52 SO_3 .37
42	Haidegersdorf, Silesia	19.21 *a*	17.87	2.96	.58	.65	2.47	....	6.18	....
43	Bayreuth, Bavaria	64.88	17.27	6.06	.91	2.19	2.15	....	6.59	Mn_2O_3 Trace.
44	Birkenweder, Graflich Magnische Mines.	57.93	8.57	3.70	14.95	1.55	....	....	12.78	CO_2 22.50
45	Neurode	55.73	42.69	.37	.28	23	50	....	.48	....
46	Eisenberg	56.40	32.80	....	....	....	2.13	....	9.10	....
47	Wiesau	47.60	34.00	1.30	Trace.	.50	3.00	....	13.60	....
48	Gröden	49.90	34.99	1.20	.50	.38	2 02	....	11.28	....
49	Saarbrücken	42.01	38.03	Trace.	....	.07	1.43	....	13.50	....
50	.....do	51.10	35.42	....	.47	.05	.56	....	12.53	....
51	.....do	48.99	37.45	Trace.	....	.06	.73	....	12.75	......
52	.....do	47.41	38.60	....	.23	.02	.49	....	13.50	....
53	.....do	45.14	38.55	....	....	1.50	.95	....	13.79	....
54	.....do	45.72	36.52	Trace.	....	1.82	1.92	....	14.08	....
55	.....do	74.62	17.58	Trace.	....	.37	1.28	....	6.26	....

a Combined silica.

Table of analyses—Continued.

GERMAN CLAYS—Continued.

Clay subs.	Quartz.	Feldspar.	Reference.	Uses.	Remarks.	
Per ct.	*Per ct*	*Per ct.*				
			Dümmler, Zieg.-Fabr'n, p. 82.		Burns red	24
	40.96		do	Front brick	Burns light yellow	25
			Dümmler, Zieg.-Fabr'n, p. 84.		Burns dark red	26
			do	Front brick	Semidry process; burns red; fuses at cone 1.	27
			do		Burns red	28
			Seger, Ges. Schrift., p. 89	Front brick	Burns light yellow	29
			Dümmler, Zieg.-Fabr'n, p. 84		Burns yellowish brown.	30
			do	Front brick, semi dry process.	Burns yellow; fuses at cone 1–2.	31
			do		Burns red	32
			do	Fire clay	Burns whitish	33
			do	Front brick	Burns yellow	34
			do	Front brick clay	Burns white	35
			Zieg. Kalendar, 1896		Burns red	36
			Dümmler, Zieg.-Fabr'n, p. 84.	Semidry pressed clay.	Burns red; fuses at cone 1.	37
			Seger, Ges Schrift., p. 89	Vitrified brick	Burns dark red	38
			Dümmler, Zieg.-Fabr'n. p. 84.		Burns yellow	39
			do		Burns red	40
			do		do	41
	50.39		do	Front brick clay	Burns light red	42
			do		Burns red	43
25.13	49.41	2.96	Thonind.-Zeit., 1891. p. 776.			44
			Ibid., p. 703	Shale fire clay		45
			Ibid., 1894, p. 539	Washed fire clay		46
88.34	8.94	2.73	Ibid., p. 358	White earthenware clay of Weiss & Co.	Burns white, but yellows at high temperatures; fuses at cone 32.	47
				Glass-pot clay of Richter & Weichelt.	Fusible at cone 34	48
	5.04		Thonindus.-Zeit., 1894	Refractory shale clays.	König, Kohlwald, and Welleswеiler pits.	49
				do		50
				do		51
				do		52
				do		53
				do		54
	50.61			do		55

Table of analyses—Continued.

GERMAN CLAYS—Continued.

	Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alkalies.	Moisture.	Ignition.	Miscellaneous.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*
56	Saarbrücken, Wellesweiler pit.	49.55	35.19	.31	.45	.31	1.13	....	13.70	....
57	Saarbrücken............	45.52	39.22	.30	.39	.11	.27	....	15.00	....
58	Wiesau..................	51.33	33.69	1.76	.90	.52	2.20	....	9.67	....
59	Gröden	66.95	26.42	.32	....	....	.58	....	6.60	....
60	Klingenberg am Main ..	49.90	33.68	1.90	.48	.44	1.81	....	11.63	SO_3 .36
61	Förderstedt bei Schönebeck.	52.55	28.26	3.46	Trace.	1.49	4.12	....	9.40	TiO_2 .37 SO_3 .27
62	Querfurt, Saxony.......	75.35	16.60	1.60	.22	.24	1.44	....	4.57	....
63	Ottweiler, Rhenish Prussia.	68.34	16.25	5.63	....	1.49	3.79	....	4.32	....
64	Siegersdorf, Silesia	69.22	16.16	6.08	Trace.	1.26	2.84	....	4.56	....
65	Hannover, province of Hannover.	65.77	15.58	5.40	1.54	1.64	2.98	....	6.81	Mn_2O_3 .31
66	Lübstorf, Mecklenburg.	51.22	14.49	5.21	7.92	2.53	3.80	....	5.16	CO_2 7.70
67	Witterschlick, near Bonn.	67.00	14.30	4.20	.70	.58	2.37	....	8.65	SO_3 1.72
68	Schönebeck, Saxony....	75.38	15.01	2.39	.80	....	2.38	....	4.84	....
69	Weissenfels, Saxony....	78.66	14.75	.75	.22	.51	.65	....	4.35	CO_2 .15
70	Liegnitz, Silesia	76.12	14.51	1.83	....	.66	1.83	....	4.94	....
71	Witterschlick, near Bonn.	71.38	13.80	1.95	.80	.60	1.88	....	6.85	SO_3 2.22
72	Constanz, Baden........	42.16	12.42	4.56	16.86	2.59	3.78	....	5.69	CO_2 12.12
73	Segenburg, Rhenish Prussia.	21.47+	14.19	2.25	Trace.	.56	1.73	....	4.87	CO_2 Tr.
74	Danzig, West Prussia ..	71.92	14.19	.45	.46	.87	2.95	....	5.20	....
75	Bockhorn, Oldenburg...	70.22	13.67	6.80	....	1.30	3.37	....	5.30	....
76	Birkenweder, Brandenburg.	48.34	11.63	4.59	15.87	1.79	2.78	....	5.28	CO_2 11.71
77	Siegersdorf, Silesia	78.26	12.93	2.68	.20	.63	.65	....	4.65	....
78	Hannover, Hannover ...	70.12	12.74	5.41	1.44	1.19	2.95	....	5.82	Mn_2O_3 .35
79	Ottersweiler, Baden	73.26	12.89	5.44	.92	1.13	1.74	....	4.24	Mn_2O_3 .37
80	Velten, Brandenburg ...	48.68	10.48	4.11	17.23	1.86	1.50	....	2.98	CO_2 13.07
81	Rathenow, Brandenburg	74.17	11.84	5.32	....	1.28	3.30	....	4.57	....
82	Osterode, Harz..........	76.70	11.93	3.57	.62	.80	4.12	....	2.25	....
83	Gerdauen, East Prussia.	64.42	10.17	3.58	8.02	2.10	1.65	....	2.36	CO_2 7.50 Mn_2O_3 .22
84	Lüdinghausen, Westphalia.	52.92	8.42	3.05	17.30	.75	.50	....	4.36	CO_2 12.70
85	Schwarzehütte, Harz ...	79.43	10.07	5.35	....	1.40	3.98	....	....	FeO .12
86	Mellentin, West Prussia	74.03	8.59	4.30	4.40	.84	2.00	....	2.40	CO_2 3.45

Table of analyses—Continued.

GERMAN CLAYS—Continued.

Clay subs.	Quartz.	Feld-spar.	Reference.	Uses.	Remarks.	
Per ct.	*Per ct.*	*Per ct.*				
	11.50					56
						57
85.20	12.56	2.24	Thonindus.-Zeit., 1894, p. 748.	Glass-pot clay		58
			Ibid., 1892, p. 212	Richter & Weichelt, glass-pot clay.	Burns yellowish gray; vitrifies at cone 10; viscous at cone 30.	59
						60
88.88	10 46	.66	Seger, Ges. Schrift., p. 870.	Front brick and sewer pipe.	Burns yellow	61
			Zieg.-Kalendar, 1896		Burns light yellow	62
			Seger, Ges. Schrift		Burns dark red	63
			Zieg.-Kalendar, 1896	Front brick	do	64
			Dümmler, Zieg.-Fabr'n, p. 86.		Burns red	65
			do		Burns yellow	66
			do	Front brick	Burns red	67
			Seger, Ges. Schrift		Burns yellow	68
			Dümmler, Zieg.-Fabr'n, p. 86.		do	69
			Seger		do	70
			Dummler, Zieg.-Fabr'n, p. 86.	Anal. of mixture used, front brick	do	71
			Zieg.-Kalendar, 1896		do	72
	54.16		Dummler, Zieg.-Fabr'n, p. 86.		do	73
			Dümmler. Zieg.-Fabr'n, p. 86.		Burns red	74
			Seg. Ges. Schr., p. 86	Vitrified paving brick.	Burns dark red	75
			Ibid., p. 86	Vitrified brick	Burns yellow	76
			Zieg.-Kalender, 1896		do	77
			Dümmler. Zieg. Fabr'n, p. 86.		Burns red	78
			do		do	79
			do	Porous stove brick	Burns yellow	80
			Zieg. Kalender, 1896	Vitrified brick	Burns red	81
			Dümmler. Zieg. Fabr'n, p. 86.	Bricks	do	82
			do		Burns yellow	83
			do	Semidry press brick.	Burns yellow; fuses cone 1-2.	84
			Seg. Ges. Schr		Burns dark red	85
			Dümmler, Zieg.-Fabr'n, p. 86.		Burns yellow	86

Table of analyses—Continued.

GERMAN CLAYS—Continued.

	Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alkalies.	Moisture.	Ignition.	Miscellaneous.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*
87	Eberswalde, Brandenburg.	71.69	2.72	3.25	5.88	1.23	3.24	....	2.41	CO_2 4.39
88	Hainstadt	83.30	10.33	.89	Trace.	....	.46	....	3.20	....
89	.....do	67.45	23.22	1.19	.98	Trace.	.51	....	6.72	....
90	Naundorf, near Rosswein.	71.73	18.64	.74	.70	.41	2.49	....	5.25	....
91	.....do	68.27	20.63	1.45	.78	.50	1.71	....	6.66	....
92	Milkel	46.61	36.47	2.81	.14	....	1.44	....	12.80	....
93	Muskau	61.34	26.17	1.77	....	1.08	2.48	....	8.07	....
94	Granau (washed clay)	71.44	18.83	1.22	....	.43	2.67	....	5.79	....
95	Ruppersdorf-Sauerman's Pits.	47.43	38.86	2.09	.77	.58	.20	....	10.72	....
96	.....do	48.54	39.12	1.73	1.35	.03	Trace.	....	9.53	....
97	.....do	46.21	39.34	1.14	Trace.	....	.69	....	12.49	....
98	Göeppersdorf v. Thielmann's Pits.	49.42	36.69	.73	.09	Trace.	.43	....	12.70	....
99	Kemnitz Saxony	59.53	29.71	.33	.12	Trace.	.61	....	10.06	....
100	Muldenstein, Meisel's brickyard.	[a]22.32	23.99	.87	.33	.48	.62	....	8.48	....
101	Lentzen a. Haff, E. Schmidt.	56.56	13.72	4.70	9.43	1.78	3.23	....	3.35	CO_2 7.33
102	Neuhof, Hecht's Pit	53.55	12.14	4.50	11.13	2.75	....	....	3.00	CO_2 8.60
103	Bernedshof, Pomm. Ind. Verein.	53.25	11.55	6.68	10.85	1.92	....	....	5.86	SO_3 .32 CO_2 8.76
104	Reichenau near Zittau, Preibisch works.	50.46	33.93	3.44	.24	.38	1.02	....	11.50	....
105	Senftenberg, Tertiary Clay.	62.70	21.30	3.06	.58	.53	2.99	....	8.57	....
106	.....do	68.36	18.03	2.79	.72	.72	2.74	....	7.54	....
107	Naumberg on the Quaiss	58.99	11.73	4.16	7.47	1.83	4.89	....	4.80	CO_2 6.19
108	Camenz i. Saxony	64.49	14.35	4.38	4.13	1.53	3.69	....	4.31	CO_2 3.12
109	Dommitzsch am Elbe	62 40	15.51	5.68	4.36	1.13	3.62	....	4.41	CO_2 2.88
110	Höhr	70.12	21.43	.77	....	.39	2.62	....	4.92	....
111	Cölln near Meissen	62.52	25.57	.92	.65	.10	1.04	....	9.27	....

[a] Combined silica.

Table of analyses—Continued.

GERMAN CLAYS—Continued.

Clay subs.	Quartz.	Feldspar.	Reference.	Uses.	Remarks.	
Per ct.	*Per ct.*	*Per ct.*				
			Zieg.-Kalender. 1896		Burns yellow	87
32.52	67.03	.45	Segers Ges. Schrift, p. 871.		Burns light yellow	88
63.92	35.56	.52				89
			Ibid., p. 881	For stoneware	Plastic clays fusing between cones 32 and 33.	90
						91
96.08	1.93	1.99	do		Fusibility cone 33	92
69.96	29.27	.77	do	Stoneware	Burns light yellow at cone .05; gray at higher temperature.	93
37.03	54.85	8.12	do	White earthenware and low-grade refractory ware.	Plasticity fair; much fine sand; fusible at cone 27.	94
94.32	3.68	2.00	Ibid., p. 891	Washed kaolin	Fairly plastic; greenish white; burns gray white; fusible between 35 and 36.	95
98.79	.36	.85	do	do	Burns light gray; fusible at cone 35.	96
97.99	.26	1.84	do	Unwashed kaolin.	Burns light yellow; fuses at cone 35.	97
89.52	3.73	6.75	do		Moderately plastic; burns white; fusible at cone 34.	98
77.64	21.58	.78	Ibid., p. 893	Used for porcelain	Burns white	99
	42.32		Ibid., p. 862		Burns ash gray	100
				Used for brick	Burns brown to red	101
				do	Burns yellow to green.	102
			Seger, Ges. Schrift, p. 862.	Brick	Burns red to yellow	103
			do	do	Burns yellow; plastic clay.	104
			Ibid., p. 378	Refractory wares.	Fat clay	105
			do	do	Raw clay	106
29.25	38.89	17.79	Ibid., p. 352	Slip clay for brown glazes.	14.07 per cent of $CaCO_3$ not included in rational analysis.	107
44.85	34.34	13.72	do	Glaze for brown earthenware.	7.09 per cent $CaCO_3$ not included in rational analysis.	108
48.21	29.27	15.98	do	Glazing		109
54.73	41.77	3.50	Ibid., p. 348	Stoneware clay		110
			Ibid., p. 343	Slip clay	Very plastic; burns nearly white.	111

Table of analyses—Continued.

GERMAN CLAYS—Continued.

	Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alkalies.	Moisture.	Ignition.	Miscellaneous.
		Per ct.	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
112	Kaschkau, E. Teighert's Pits.	63.17	25.09	0.64	0.35	0.26	0.80	....	9.70	....
113	Mühlenbeck, Holzhüter Pits.	42.31	9.91	4.88	19.95	1.86	1.66	....	8.52	CO_2 15.71
114	.....do	41.03	10.09	4.20	20.99	2.14	1.64	....	3.10	CO_2 16.81
115	Velten	47.86	11.90	5.18	14.96	1.71	3.66	....	4.64	CO_2 10.44
116	.....do	43.48	10.46	5.10	18.68	1.42	4.00	....	{Ign. and CO_2 16.98}	....
117	Neuhof near Stralsund	55.02	13.90	4.53	10.95	1.76	1.48	....	3.31	CO_2 8.64
118	Oberjahna	83.78	10.75	.55	....	.64	.54	....	3.94	....
119	Frankenthal on Rhine	41.90	31.69	2.54	....	....	2.22	3.20	9.45	TiO_2 .90

ENGLISH CLAYS.

1	Stourbridge, Worcester Co.	46.10	38.80	....	....	....	....	....	14.60	....
2	.....do	69.00	22.00	*a*1.50	0.49	0.54	.59	....	7.00	....
3	.....do	30.50	22.52	1.43	....	....	.50	2.10	8.30	{TiO_2 1.00}
4	Stannington near Sheffield.	48.04	34.47	3.05	.66	.45	1.94	....	11.15	....
5	Brierley Hill	51.80	30.40	4.14	....	.50	....	....	13.11	....
6	Gartshire	59.48	28.95	1.05	Tr.	....	....	....	11.05	....
7	North Yorkshire	72.25	18.08	....	.39	.02	.61	....	....	....
8	Coatbridge, Scotland	65.41	30.55	1.70	.69	.64	.65	....	....	{TiO_2 1.33}
9	Hexham	59.05	25.61	*a*2.20	.88	.75	2.25	....	7.44	{TiO_2 1.53}
10	Halifax, Yorkshire Co	39.45	32.19	2.65	....	....	.51	1.60	11.80	....

a Iron determined as FeO.

FRENCH AND BELGIAN CLAYS.

1	Limoges, France	66.71	21.58	0.47	0.61	0.37	4.55	....	5.54	....
2	.....do	58.39	27.52	.36	1.52	.41	4.29	....	7.19	....
3	Abondant, near Dreux, France.	50.60	35.20	.40	....	....	....	....	13.80	....
4	Marseilles, France	38.00	24.00	4.50	11.00	.80	....	....	{Ign. and CO_2. 21.70}	....

Table of analyses—Continued.

GERMAN CLAYS—Continued.

Clay subs.	Quartz.	Feld-spar.	Reference.	Uses.	Remarks.	
Per ct.	*Per ct.*	*Per ct.*				
67.82	30.93	1.25	Seger, Ges. Schrift., p. 344.	Slip clay	Total shrinkage 4.4 per cent washed clay.	112
			Ibid., p. 340	Used for stoves	Yellow clay; total shrinkage 4 6 up to 1,700° F.	113
			do	do	Under gray clay; total shrinkage 3.4 per cent up to 1,704° F.	114
			do	do	Total shrinkage 6 per cent up to 1,700° F.	115
			do	do	This and three preceding all very plastic.	116
			Ibid., p. 91	Used for brick	Burns yellow	117
30.55	66.61	2.84	Thonindus. Zeit., 1890, p. 592.	For white earthenware when washed.	Burns white	118
83 04	8.10		Mon. XXVII. U. S. G. S., p. 388.	Refractory wares		119

ENGLISH CLAYS.

			Kerl, Handb. d. Thonwaaren-industrie, 1879.	Refractory goods	Burns white	1
			Jour. Soc. Chem. Ind. 1892, p. 17.	Crucibles		2
61.32	33.65		Mon., XXVII, U. S. G. S.	Glass pots	A very strong clay	3
			Kerl, Handb. d. Thonwaaren-industrie, 1879.	Refractory goods		4
			do	do	Henry, analyst	5
			do	do	Schwarz, analyst	6
			British Clayworker, July, 1896.	Paving brick	Burns red	7
				Refractory wares	Glenboig Union Fire Clay Co.; E. Riley, analyst.	8
			Jour. Soc. Chem. Ind. 1892, p. 17.	Crucibles		9
83.44	11.80		do	Crucible fire clay; also cupola linings.		10

FRENCH AND BELGIAN CLAYS.

43.04	26.46	30.50	Seger Ges. Schrift., p. 553.	Porcelain mixture		1
55.88	5.95	38.17	Ibid., p. 552	Porcelain	Kaolin	2
			Dümmler, Zieg.-Fabr'n, p. 80.	Refractory wares		3
			do	do		4

Table of analyses—Continued.

FRENCH AND BELGIAN CLAYS—Continued.

	Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alkalies.	Moisture.	Ignition.	Miscellaneous.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
5	Livornon, France	49.00	24.00	6.26	2.00	....	....	....	18.00	....
6	Salavas, France	58.76	25.10	2.50	Trace.	2.51	....	....	12.50	....
7	Montereau, France	64.40	24.60	Trace.	....	....	....	....	10.00	....
8	Boulogne, France	69.42	18.00	.95	2.00	3.27	....	....	6.28	....
9	Grand Pré, France	58.50	13.50	8.33	5.19	1.35	....	....	13.13	....
10	Bollène, Dept. de Vaucluse, France.	32.80	28.19	2.76	....	....	.40	3.60	10.50	TiO_2 0.15
11	Forges les Eaux, France.	76.99	19.67	.84	1.50	.40	....	....	.60	....
12	Andennes, Belgium	49.64	34.78	1.80	1.68	.41	.41	....	12.00	....
13	Stoud Maiseroul, Belgium.	49.64	34.78	1.80	.68	.41	.41	....	12.00	....

SWEDISH CLAYS.

1	Scania	50.86	30.02	2.08	0.10	0.67	0.99	....	14.98	TiO_2 .46
2	Helsingborg	60.70	20.45	7.98	.55	.47	....	....	9.27	....
3	Ifö	46.88	37.22	1.31	.21	....	.40	....	14.12	....
4	.....do	47.53	35.51	2.48	1.08	....	.42	....	13.15	....
5	.....do	53.00	42.00	.45	.12	.18	.89	2.30	....	....

DANISH CLAYS.

1	Bornholm	72.50	19.50	1.00	.18	.50	....	....	6.19	....
2	.....do	41.53	39.17	.58	.07	.02	.86	....	13.86	....

RUSSIAN CLAYS.

1	Borowitschii, Nowgorod	38.10	41.10	1.81	0.24	0.09	4.73	1.00	13.97	....
2	Shdany	48.93	36.56	1.68	.66	.56	.19	....	11.65	....
3	Gluchow, Gouv. Tschernigow.	50.37	32.30	.61	.41	.62	.49	....	14.17	Mn_2O_3 .17 Org. .50
4	Blagodatnoje, S. Russia.	55.83	26.04	Trace.	.66	.32	.87	CO_2 .37	13.50	Org. 2.21
5	Shdany	53.93	25.76	4.88	.77	.52	.26	....	14.31	....
6	Blagodatnoje	59.65	22.11	1.12	.80	.47	1.20	CO_2 .43	11.02	Org. 3.20
7	Sawidowa, Gvt. Yekaterinoslaw.	62.73	22.64	.80	.43	.28	1.11	CO_2 .17	9.70	Org. 1.80
8	Gschelj, near Moscow	65.18	22.52	2.20	.27	.44	....	CO_2 .67	7.90	....
9	Borowitschii	73.46	15.79	.27	.71	1.25	2.67	....	5.97	....

Table of analyses—Continued.

FRENCH AND BELGIAN CLAYS—Continued.

Clay subs.	Quartz.	Feldspar.	Reference.	Uses.	Remarks.	
Per ct.	*Per ct.*	*Per ct.*				
			J. Foy, La Céramique des Constructions, 1883.	Roofing tiles		5
			E. Lejune, Guide du Briq. et du Chauf.		Burns red	6
			C. Bischof, Die feuerfesten Thone, 1895.	Refractory wares.	Fusible at cone 33	7
			E. Lejune, Guide du Briq. et du Chauf.	Crucibles		8
			do	Stoneware		9
			do			10
			do	Roofing tiles		11
76.89	14.95		Mon. XXVII, U. S. Geol. Surv., p. 388.	For tuyeres and steel furnace hearths.	Used one-third burnt and one-third crude, with one-third quartz.	12
			Thonind.-Zeit., 1898, p. 687.	Porcelain clay		13

SWEDISH CLAYS.

Clay subs.	Quartz.	Feldspar.	Reference.	Uses.	Remarks.	
			Thonind.-Zeit., 1889, No. 49	Refractory wares.	H. Hecht, analyst	1
			Dümmler, Zieg.-Fabr'n, p. 84.			2
			From specimen at Stockholm exposition.	Refractory wares.	Washed kaolin	3
			do	do	Burns red	4
			do	do	Red kaolin, probably burned.	5

DANISH CLAYS.

Clay subs.	Quartz.	Feldspar.	Reference.	Uses.	Remarks.	
			Dümmler, Zieg.-Fabr'n, p. 84.	Refractory wares.		1
	4.04		C. Bischof		Kaolin	2

RUSSIAN CLAYS.

Clay subs.	Quartz.	Feldspar.	Reference.	Uses.	Remarks.	
			Dümmler, Zieg.-Fabr'n, p. 80.	Refractory wares.	Burns white	1
			do	Faience		2
			do	Refractory wares.	Burns whitish	3
			Ibid., p. 82	do	Kaolin	4
			do	For saggars	Burns reddish	5
			do		Kaolin	6
			do		do	7
			Ibid., p. 84	Faience		8
			C Bischof, Deut. Töp. u. Zieg.Zeit., 1891, No. 221.	Sewer pipe	Burns white	9

THE CLAY-WORKING INDUSTRY OF THE UNITED STATES IN 1897.

By HEINRICH RIES.

INTRODUCTION.

The greatest signs of activity during the past year have come from the potters, who claim great improvement in their business. Several of the works at East Liverpool, Ohio, have enlarged their plants, and new works have been erected at Chittenango, New York; Ford City, Pennsylvania; Fort Negley, Tennessee, and Toronto, Indiana.

Two potteries, the Rookwood Pottery and the Wheeling Pottery Company, are using thermo-electric pyrometers for determining the temperatures of their kilns during burning.

The use of Seger's cones for controlling the burning of the wares is slowly extending among American clay workers.

Happily the National Brick Manufacturers' Association has voted to continue the experiments for determining the effect of structure on the wearing power of a brick.

THE CLAY-WORKING INDUSTRY IN THE VARIOUS STATES.

ALABAMA.

In last year's report[1] there was given an abstract of a number of chemical and physical tests which had been made on clays from Alabama. Since then a number of additional samples have been examined with very satisfactory results. These tests, which are still being carried on, will serve as the preliminary work on a bulletin on the Clays of Alabama.

Of special interest are the fire tests which have been made on a series of bauxite samples. All of these, with but one exception, were unaffected by exposure to a temperature of 3,000° F. in the Deville furnace.

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[1] The Clay-Working Industry in the United States for 1896, by H. Ries: Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, pp. 1128-1129.

Recent railroad excavations for the Mobile and Ohio Railroad have developed thick beds of clay 10 miles west of Tuscaloosa. Excellent buff-burning clays occur in the vicinity of Oxford, and terra-cotta clays near Choccolocco.

The kaolins, 7 miles north of Valley Head, on the Alabama Great Southern Railroad, are once more being mined for the manufacture of white earthenware.

ARKANSAS.

In a paper on the "Cement materials of southwest Arkansas"[1] Prof. J. C. Branner discusses the distribution of the clays in the southwestern part of the State. The Tertiary rocks contain an abundance of good clays, which are being utilized for the manufacture of pottery at Benton and Malvern. Unworked deposits occur at Arkadelphia; also between Benton and Bryant, and at Mabelvale. The beds of clay and clay shales are very extensive around Little Rock and along the Little Rock and Fort Smith Railroad. At Little Rock both Tertiary clays and Carboniferous shales are found.

The following analyses of clays, shales, and fuller's earths are quoted from Professor Brauner's paper:

Analyses of typical Carboniferous clay shales from Arkansas.

	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Na_2O.	K_2O.	H_2O.	Sand.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	53.30	23.29	9.52	0.36	1.49	2.76	1.36	5.16	....
2	62.36	25.52	2.16	.51	.29	.66	1.90	5.32	....
3	65.12	19.05	7.66	.34	.31	.85	1.23	6.12	21.88
4	57.12	24.32	8.21	.72	1.74	.53	2.07	7.58	....
5	55.36	26.96	5.12	.30	1.16	1.03	2.69	7.90	....
6	51.30	24.69	10.57	.32	.63	.72	2.18	9.11	....
7	69.34	22.56	1.41	Trace.	Trace.	2.31	.04	5.12	....

1. Railroad cut at south end of upper bridge, Little Rock.
2. Decayed shale, Iron Mountain Railroad cut, at crossing of Mount Ida road, Little Rock.
3. Harding & Boucher's quarry, Fort Smith.
4. Round Mountain, White County, sec. 6, 5 N., 10 W.
5. Clarksville, east of college.
6. SE. quarter of SW. ¼ sec. 31, 10 N., 23 W.
7. NW. ¼ sec. 23, 1 N., 13 W.

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[1] Trans. Amer. Inst. Min. Eng., Feb., 1897.

Analyses of typical Tertiary clays from Arkansas.

	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Na_2O.	K_2O.	H_2O.	Miscel.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	63.07	23.92	1.94	0.23	Trace.	1.08	1.15	7.07	....
2	72.44	18.97	1.59	.18	Trace.	.91	1.35	5.39	....
3	69.95	22.34	1.44	Trace.	.08	1.18	1.28	5.98	....
4	71.09	19.86	1.81	.11	....	.81	1.45	5.67	....
5	65.27	18.75	7.34	.81	1.26	.81	1.10	6.88	....
6	64.38	17.29	8.25	1.11	.80	.42	1.41	6.95	....
7	63.19	18.76	7.05	.78	1.68	1.50	.21	7.57	....
8	64.49	23.86	2.11	.31	Trace.	1.82	.11	8.11	....
9	67.90	22.07	1.33	.05	.59	.38	1.15	6.86	....
10	48.34	34.58	1.65	.81	Trace.	1.26	.44	12.94	TiO_2 1.56
11	62.34	20.63	3.34	.17	.67	.33	.73	9.34	TiO_2 1.49
12	68.03	17.19	3.00	.81	1.00	.54	1.00	6.31	....
13	63.29	18.19	6.45	.31	2.44	Trace.	.56	....	....
14	76.33	16.04	1.24	By dif. 0.99				5.40	....
15	75.99	16.12	1.35	By dif. 1.45				....	....
16	73.24	19.61	1.04	By dif. .78				....	....
17	45.28	37.39	1.71	1.83	.29	....	....	13.49	....

1. Benton, Hick's bed, 2 S., 15 W., sec. 12.
2. Benton, Rodenbaugh, 2 S., 15 W., sec. 12
3. Benton, Herrick & Davis's bank.
4. Benton, Henderson's pit, upper bed.
5. Mabelvale, from Mr. A. W. Norris's well.
6. Olsen's switch, fuller's earth.
7. Fuller's earth, Alexander, 1 S., 13 W., sec. 8, SW. of SE.
8. Benton, Woolsey's clay.
9. Ridgwood, 1 N., 12 W., sec. 25, SW. ¼ of NE. ¼.
10. Benton, Howe's pottery.
11. Clay from 8 S., 15 W., sec. 4.
12. Clay from 8 S., 15 W., sec. 5.
13. Clay from 2 S., 13 W., sec. 13, S. ½
14. John Foley's, 13 S., 24 W., sec. 18, NE. of SE.
15. Climax pottery, 15 S., 28 W., sec. 5, W. ½ SE. ¼.
16. Atchison's, 4 S., 17 W., sec. 24, NE. ¼ of NE ¼.
17. Kaolin, 1 N., 12 W., sec. 36, Tarpleys.

INDIANA.

The work on the clays of Indiana, which was actively pushed in 1895 and 1896, has been continued in 1897. During this last season the State geologist has carried on field work on the clays of northwestern Indiana.[1] The paper cited deals with the more important clay deposits of Benton, Newton, Jasper, Starke, Lake, Porter, Laporte, and St. Joseph counties.

The clay deposits of Benton County are of glacial origin, and are said to vary in thickness from 5 to 130 feet, and an important deposit occurs at Earl Park. Hollow brick are manufactured there, and drain tile at Fowler. Newton County contains both glacial and marly clays, which are worked at Morocco, Mount Ayr, and Brook. At the latter locality terra-cotta lumber is manufactured. Unworked beds of marly clay occur along the Iroquois River, east and west of Brook. The clays of Jasper County are of a similar nature. In Starke County a fine-grained, blue bowlder clay occurs everywhere beneath the prairie sod and marsh bottoms.

In Lake County the drift clays are utilized at Lowell and Crown Point for making brick and drain tile, and at Hobart the silty clays are much used for terra-cotta lumber, flue lining, fire proofing, and ordinary and pressed front brick.

The Porter County clays are also both glacial and marly clays. The drift clays are used for common brick and drain tile at Hebron and Valparaiso; the marly clays are made into pressed brick at Porter, and common brick at Garden City and Chesterton. The hydraulic-press brick plant at Porter is very extensive.

At Chesterton brick and tile are made from a calcareous buff-burning clay similar to that used at Hobart. Similar clays also occur around Michigan City in Laporte County.

Around South Bend, in St. Joseph County, are thick deposits of pearl gray marly clay of a very fine-grained plastic nature. They burn to a light yellow building brick or a greenish yellow paving brick.

In Jackson County the Knobstone shale is of considerable importance, especially near Surprise and south of Freetown. This shale, it is considered by Professor Blatchley, will probably make good paving brick.

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[1] The Clays and Clay Industries of Northwestern Indiana, by W. S. Blatchley: Twenty-second Rept. Dept. of Geol. and Natural Resources, p. 105.

The following are analyses of several of the more important clays in the counties which have been mentioned above:

Analyses of Indiana clays.

	From Hobart, Lake County.		From Garden City, Porter County.		From Chesterton, Porter County.		From Michigan City, Laporte County.		From Blue Lick, Jackson County.	
	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
SiO_2	50.56	34.35	50.37	35.62	53.02	35.21	50.47	30.20	59.64	30.22
TiO_2	1.00	......	.65	......	1.30	......	1.45	......	1.05	....
Al_2O_3	13.11	3.06	9.93	1.95	10.72	2.94	12.77	2.51	19.14	1.61
H_2O	2.76	......	1.50	......	2.21	......	3.14	......	4.36	....
Fe_2O_3	2.98	......	2.10	......	2.54	......	2.44	......	3.39	....
FeO	2.32	......	2.05	......	2.22	......	2.52	......	4.20	....
CaO	7.87	2.14	10.26	2.35	8.38	1.65	8.17	1.38	.26	.60
MgO	5.06		6.26		5.28		5.22		2.31	
K_2O	3.74		3.04		3.25		3.70		3.53	
Na_2O	.70		.79		.86		.73		.80	
CO_2	9.62	......	12.50	......	10.48	......	9.80	......	.35	....
Total	99.72	39.55	99.45	39.92	100.26	39.80	100.41	34.09	99.03	32.43
	Rational analyses of above clays.									
Quartz	23.61	......	28.78	......	24.89	......	21.39	......	25.57	....
Feldspathic detritus	15.94	......	11.14	......	14.91	......	12.70	......	6.86	....
Calcium carbonate	14.05	......	18.32	......	14.86	......	14.59	......	......	....
Magnesium carbonate	6.54	......	8.48	......	7.60	......	6.42	......	.67	....
Clay substance	39.86	......	33.28	......	37.74	......	44.90	......	66.90	....

IOWA.

In the report of the Iowa Geological Survey,[1] recently issued, Mr. Bain makes detailed mention of the important clay resources of Polk County. The formations yielding clays suitable for the manufacture of clay products are those of the coal measures and Pleistocene. The alluvium is extensively developed along the streams, and is an easily worked material. The loess is used chiefly for common brick. It is highly siliceous and contains much lime, but works well with the dry-press process, and if carefully treated can be molded even in stiff-mud machines. It will not stand rapid drying.

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[1] Geology of Polk County, H. F. Bain, Iowa Geol. Survey, Vol. VII, p. 366.

The Coal Measures supply the greater portion of the clay used in the county, and a number of varieties, serving different purposes, are obtained. The products at present made are building and paving brick, sewer pipe, drain tile, and common pottery. Mr. Bain reports that some of the Coal Measure clays are eminently adapted to serve as ball clays in the manufacture of white earthenware.

Paving bricks are extensively manufactured in the vicinity of Des Moines, and a number of tests have recently been made on the raw and manufactured materials of the Des Moines paving-brick plants. The data are so complete they are reproduced here in detail. In the first table is given a general summary of the brick tests. The tests made were abrasion in rattler, absorption, and transverse strength. The latter is expressed in terms of the modulus of rupture. The rattler used was polygonal in form, 29 inches in diameter, and 48 inches long. It was charged with eleven bricks and a standard charge made up of 300 pounds of 2-pound cubes, 340 pounds of cast-iron spheres, and 120 pounds of smooth cast-iron foundry shot, one-fourth to one-half pound each in weight. The test consisted of 800 revolutions at a rate of 33 revolutions per minute.

The absorption test was made upon brick which had been subjected to the rattler treatment. They were dried at 174° to 178° F. for seventy-two hours, and cooled one hour at 60° F.

Tests of paving bricks from Des Moines, Iowa.

Name of manufacturer.	Method of manufacture.	Abrasion and impact, rattler test.			Porosity absorption.	Transverse-strength rupture.			Comparative rating by formula.
		Averages.							
		Per cent of loss.				Modulus of rupture. Pounds.			
		Actual.	Rational.	Average.	Per cent of gain.	Actual.	Rational.	Average.	
Des Moines Brick Manufacturing Co., Des Moines.	End cut...	11.07	11.07	11.07	0.93	2,584	2,584	2,584	89.36
	Common..	12.80	12.13	12.49	1.17	2,681	2,681	2,681	80.39
Capital City Brick and Pipe Co., Des Moines	End cut...	17.78	17.61	17.70	.54	3,896	4,080	3,988	62.89
	Common..	12.49	12.49	12.49	.60	3,429	3,429	3,429	89.82
Iowa Brick Co., Des Moines.	End cut...	12.28	11.45	11.87	.80	......	......	......	80.61
	Common..	16.80	15.65	16.23	.86	2,193	2,193	2,193	54.21
Do..............	Side cut ..	12.23	11.81	12.02	.55	......	......	......	92.12
	Re-press..	14.80	13.63	14.22	.96	3,348	3,714	3,531	77.28
Flint Brick Co., Des Moines.	End cut...	......	......	......	......	......	......	......	......
	Common..	12.49	12.49	12.49	.93	2,740	2,740	2,740	82.25
Davenport Paving Brick and Tile Co., Davenport.	End cut...	......	......	......	......	......	......	......	......
	Common..	15.08	14.67	14.85	.93	2,056	2,056	2,056	61.88
Ottumwa Paving Brick Co., Ottumwa.	End cut...	......	......	......	......	......	......	......	......
	Common..	12.95	12.95	12.95	2.10	2,343	2,343	2,343	71.20

The chemical composition of the different beds at the mines of the companies mentioned in the preceding table is as follows:

Analyses of clays from various beds of the Des Moines Brick Manufacturing Company.

Bed.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alk.	H_2O.	Moist.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*
1	70.29	15.18	7.32	0.80	1.72	1.49	2.18	1.02
2	59.18	21.63	9.00	1.06	1.85	1.52	3.80	1.95
3	64.60	19.20	7.68	1.02	1.37	1.25	3.95	.92
4	64.41	20.43	5.88	.34	1.71	1.90	3.93	1.27
5	63.23	24.52	5.28	.32	.99	1.16	2.55	1.75
6	76.01	11.94	5.40	1.57	1.04	1.80	1.41	.65
7	67.76	14.46	8.52	1.16	2.36	1.24	3.53	.67
8	55.56	21.33	10.56	1.59	2.94	2.38	4.65	.97

1. Top clay, worked; variegated, highly refractory, burning to a brick of medium toughness, high porosity, and low breaking strength; thickness, 3 to 8 feet; average, 5 feet.

2. Shale, streaked in color, medium fusibility, high in iron and fluxes; burns to a brick of medium toughness, medium porosity, and low resistance to rupture; thickness, 3 to 8 feet; average, 4 feet.

3. Shale, solid chocolate brown color; clear definition; brick shows medium toughness, low porosity, and high modulus of rupture; thickness, 5 feet.

4. Shale, solid color; an average clay with medium iron, and fluxes lower than the clays above; bricks show low toughness, low porosity, high modulus of rupture; thickness, 5 feet.

5. Shale, variegated; low iron and fluxes, high alumina; bricks show medium toughness, low absorption, high modulus of rupture; 3 feet thick.

6. Shale, sandy; bricks show low toughness, low absorption, medium modulus of rupture; thickness, 10 feet.

7. Shale, sandy, granular; pulverizes in the hand.

8. Bottom shale, gray, easily fused. This is worked. Gives bricks of good toughness, high porosity, low modulus of rupture.

Analyses of shales from various beds of the Flint Brick Company, Des Moines

Bed.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alk.	H_2O.	Moisture.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	70.23	15.68	7.44	.47	1.50	1.26	1.82	1.50
2	69.89	17.68	5.68	1.05	1.68	1.15	1.97	.85
3	58.92	21.45	8.40	.98	2.90	2.49	4.13	.57
4	50.38	27.25	11.54	.96	2.93	1.65	3.62	1.45
5	62.70	21.32	5.88	.16	1.77	1.15	4.90	2.12
6	64.31	17.64	7.68	1.12	2.40	1.15	5.47	.42
7	64.03	20.73	6.72	.36	2.57	1.30	3.50	.42

The above are all shales, No. 1 being at the top.

Analyses of shales from various beds of the Iowa Brick Company, Des Moines.

Bed.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alk.	H_2O.	Moisture.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	55.98	25.65	5.88	.74	1.88	1.95	3.73	3.72
2	81.79	10.25	3.24	.52	.57	1.75	1 27	.58
3	68.50	18.45	5.28	1.19	1.42	1.27	2.82	.88
4	52.88	24.27	11.28	.52	2.03	1.92	3.28	3.46
5	66.73	20.28	3.24	.70	.90	1.46	4.92	1.70
6	64.60	20.25	6.72	1.20	1.02	1.33	3.74	1.14
7	64.82	21.00	5.76	.42	2.48	2.11	3.10	.33
8	57.25	22.50	7.92	.90	2.28	1.41	3.62	3.88
9	53.05	25.92	8.76	1.00	2.73	1.29	4.40	2.70

1. Shale, variegated, reddish brown, mahogany reds, yellowish, bluish drab, dark gray, almost black; the colors mottled parallel to bed; thickness, 6 feet.
2. Sandy, light yellowish white; thickness, 6 feet.
3. Slightly sandy at top to clear shale below; thickness, 5 feet.
4. Shale, clear chocolate brown; thickness, 4 feet.
5. Shale, granular, dark solid drab with purplish nodules; thickness, 3 feet.
6. Shale, bluish drab; thickness, 6 feet.
7. Same as No. 6.
8 Shale, drab, green, and chocolate brown; thickness, 6 feet.
9. Clear dark drab with olive-green tinge; thickness, 2 feet.

Analyses of clay from various beds of the Capitol City Brick and Tile Works, Des Moines.

Bed.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alk.	H_2O.	Moisture.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	55 25	25.60	5.52	1.75	1.49	1.79	5.07	3.27
2	53.06	24.93	9.00	.94	1.84	1.19	5.73	3.29
3	61.18	21.69	5.88	.51	1.92	1.96	5.01	1.27
4	68 60	18.93	6.12	.25	.68	.74	2.80	1.80
5	65.62	16.83	8.64	.42	2.00	1.66	4.10	.60
6	51.35	27.38	6.60	1.45	2.62	2.34	5.42	2.81
7	58.42	20.04	7.80	1.60	2.67	1.56	5.40	2.39

1. Clear, medium light drab shale, very slightly gritty; thickness, 7 feet.
2. Shale, mottled coloring; thickness, 4½ feet.
3 Shale, bluish drab; thickness, 7 feet.
4. Bastard fire clay, purplish blue and dark gray; thickness, 4 feet.
5. Shale, soapy, with some grit; greenish gray; thickness, 15 feet.
6. Shale, dark greenish gray; thickness, 1½ feet.
7 Shale, clear blue sandy.

The various brick, tile, and pottery works located in the county are described in detail by Mr. Bain.

NEW YORK.

A number of experiments have been made by Mr. H H. Griffen[1] to determine in what manner it is possible to lower the fusibility of slip clay and make it run more easily without destroying its richness of color. The addition of lead alone gave a transparent and greenish colored glaze which showed a tendency to blister; alkali added alone gave the same result. It is, therefore, necessary to add other materials with the lead.

In the following table is given an analysis of slip clay from Albany, New York:

Analysis of Albany slip clay.

	Per cent.
Silica	17.02
Alumina	14.80
Ferric oxide	5.85
Manganic oxide	.14
Lime	5.70
Magnesia	2.48
Potash	3.23
Soda	1.07
Phosphoric acid	.15
Water	5.18
Moisture and carbonic acid	4.94
Sand	38.58
Total	99.14

As this clay approaches closely to the formula—

$$1\ RO,\ .7R_2O_3,\ 4\ SiO_2,$$

which is similar to that of an alkaline glaze, but with an excess of R_2O_3, the addition of lead increases this excess of bases, and it is necessary to add silica also. We must in addition, however, add some coloring matter, to counteract the bleaching action of the lead. Good results were obtained by adding iron alone, but the combination of chromium, manganese, and iron produced the best effect. The chromium, Mr. Griffen finds, takes from the iron its tendency to run into greenish and yellowish tints. The best form in which to introduce the chromium is as chromate of lead, this giving the best color effect; but as an excess of this salt also has a tendency to cause blistering, it is best to add some of the chromium in the form of chromate of iron.

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[1] The Clay Worker, Vol. XXVIII, No. 3, September, 1897, p. 178.

The following receipt is for a moderately low heat glaze, the variations being for different conditions:

Receipt for moderately low heat glaze.

	Per cent.
Albany slip clay	63.3 to 70.0
White lead	25.3 to 17.4
Flint	6.3 to 7.0
Oxide of iron	.72 to .79
Oxide of manganese	.56 to .61
Chromate of lead	1.27 to 1.40
Chromate of iron	.67 to .73
Oxide of zinc	1.88 to 2.07
Total	100.00 100.00

NORTH CAROLINA.

According to a recently published bulletin of the North Carolina Geological Survey[1] the clay deposits of the State may be divided into—

Residual: Kaolins, fire clays, and impure clays.

Sedimentary: Coastal plain clays of Cretaceous or Tertiary age. Sedimentary surface clays (for brick and pottery), are found mainly along the streams and lowlands in the Piedmont plateau and mountain counties.

RESIDUAL CLAYS.

The residual clays occur in the western half of the State, west of a line passing through Weldon, Raleigh, and Rockingham. They form an almost universal mantle over the surface and vary in thickness from 3 to 20 feet. The analyses given in the table of the clays at Dean's yard and that of the Greensboro Brick and Tile Company, both at Greensboro, indicate their composition. These impure residual clays were generally found to be sandy, and very porous. With proper machinery and treatment they yield a good grade of brick.

The residual fire clays found at Pomona and Grover are coarse-grained clays, with much intermixed quartz and mica.

The kaolins are of special importance and of superior quality. The most important mines are at Webster and west of Sylva.

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[1] The Clays and Clay Industry of North Carolina, by H. Ries, Bull. No. 13, N. C. Geol. Survey.

The following tables will indicate the composition of the North Carolina kaolins:

Variation in composition of washed kaolins from North Carolina.

	Per cent.
Silica	44.08 to 86.03
Alumina	6.46 to 41.70
Ferric oxide	.28 to 2.97
Lime	.15 to .50
Magnesia	.09 to .20
Alkalies	.25 to 2.48
Water (loss on ignition)	2.90 to 13.56

Per cent of ferric oxide in kaolin and color when burned.

Locality.	Ferric oxide.	Color of burned kaolin.
	Per cent.	
G. Springer, Webster (*a*)	0.28	White.
West's Mill	1.18	Do.
Harris Clay Co., Webster	1.41	Do.
Sylva	1.86	Do.
Bostick's Mills	2.14	White, faint yellow tinge.
Dark kaolin, Troy	2.18	Light buff.
White kaolin, Troy	2.97	Red buff.

[a] Also contains 1.08 per cent FeO.

Composition of North Carolina kaolins.

Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alk.	Moist.	H_2O	Clay substance.	Quartz.	Feldspar.
North Carolina Mining and Manufacturing Company, Sylva:	*Per cent*	*Per cent*	*Per cent*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*
Washed kaolin	44.08	36.26	1.86	0.43	0.20	0.50	3.07	13.56	94.21	5.75	
Harris Clay Company, Webster:											
Washed kaolin	45.70	40.61	1.39	.45	.09	2.82	.35	8.98	96.81	.07	3.12
G. Springer, Webster:											
Crude kaolin	62.40	26.51	1.14	.57	.01	.98	.25	8.80	66.14	15.61	18.91
Clay substance of above	50.50	34.24	.74	.86	.01	.10	....	13.35	....	....	....
Washed kaolin	45.78	36.46	FeO 1.08 .28	.50	.04	.25	2.05	13.40	93.24	6.60	
G. Brindels, West Mills:											
Crude koalin	53.10	33.06	1.18	38	08	.83	....	11.82	83.39	14.98	1.58
Clay substance	45.41	39.56	.86	.45	.09	.03	....	13.58	....	....	....
Four miles west of Troy:											
Crude, dark kaolin	90.13	4.99	1.86	.13	.01	1.03	.48	1.93	14.71	83.94	1.91
Clay substance and Fe_2O_3	38.58	33.66	10.46	.91	.07	2.70	....	13.56	....	....	....
Washed dark kaolin	86.03	6.46	2.14	.17	.04	1.00	....	2.90	20.83	76.20	2.34
Clay substance and Fe_2O_3	43.46	30.04	9.30	.84	.19	1.33	....	14.35	....	....	....
Washed white kaolin	63.10	23.33	2.97	.15	.09	1.90	....	7.65	58.92	35.27	5.81
Bosticks Mills:											
Crude kaolin, 21	68.15	19.99	1.86	.13	.16	2.85	.17	4.70	49.30	41.50	9.20
Crude kaolin, 20	70.63	21.81	1.49	.20	.29	1.45	.08	4.04	47.14	36.73	16.13
Clay substance	47.88	39.04	1.90	.42	.60	1.04	....	8.58	....	....	....
Crude kaolin, 22	73.70	16.03	1.57	.38	.47	1.90	....	4.33	36.05	62.33	
No. 20 washed	71.12	19.61	2.18	.17	.08	2.48	....	4.33	54.30	43.85	1.82
Clay substance	49.33	35.90	3.15	.31	.14	3.15	....	8.00	....	....	....

SEDIMENTARY CLAYS.

The coastal plain deposits of North Carolina furnish the most extensive beds of clay to be found within the State. They have been classed as belonging to Cretaceous, Eocene, and Pleistocene formations. The Potomac clays (Cretaceous) are exposed at Prospect Hall, on the Cape Fear River, and the Eocene beds are well shown in railroad cuts between Spout Springs and Fayetteville.

Many clays suitable for the manufacture of brick and pottery are found underlying the river terraces farther inland. Such terraces are abundant along the Catawba River near Morgantown and Mount Holly; along the Yadkin River, especially at Wilkesboro and Elkin, and along the Clarke River at Lincolnton, where much stoneware clay is dug.

Sedimentary clays are also especially well developed around Wilson, Goldsboro, and Fayetteville. With proper treatment these clays yield excellent results, but careless methods develop a very inferior product.

CLAY PRODUCTS MANUFACTURED IN NORTH CAROLINA.

These include stoneware, earthenware, fire brick, sewer pipe, flue linings, draintile, and building brick.

Stoneware is manufactured at a number of small potteries, but the grade is not nearly as high as could be produced from the clay.

Sewer pipe and flue linings are produced in considerable quantities at Pomona, and the clays mined at Grover make an excellent grade of white face-brick, and one which has been found to be free from subsequent discoloration.

Common brick are made at many localities throughout the State, but pressed brick have not passed beyond the experimental stage, although the clays are often admirably adapted to it.

CLAY ANALYSES.

The following tables show analyses of North Carolina clays:

Analyses of North Carolina clays.

BRICK CLAYS.

Locality.	Insol. residue.	Total silica.	Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Moist.	Water.	Total fluxes.	Miscellaneous.	Remarks.	Firm name, authority, or analyst.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
Prospect Hall, Bladen County	27.18	56.13	17.80	5.85	0.10	0.79	2.45	4.50	11.60	7.29	....	Upper brick clay	Bull. 13, N. C. Geol. Surv., p. 102.
Do	57.30	63.30	15.87	5.48	.27	.21	2.40	2.80	8.25	10.14	Sulphur, 1.78.	Middle brick clay	Ibid., p. 103.
Do	15.05	55.65	20.86	5.11	.30	.64	2.13	4.26	9.94	9.36	Sulphur, 1.18.	Lower brick clay	Do.
Emma, Buncombe County	50.40	66.27	19.95	3.16	.20	.32	1.85	1.15	6.17	6.20	Ferrous oxide, 0.67.	Upper clay, Penniman's yard	Ibid., p. 104.
Do	41.71	70.66	17.21	3.44	.10	.07	2.45	.80	.05	7.16	....	Lower clay, Penniman's yard	Ibid., p. 105.
Fletcher, Buncombe County	45.18	75.08	13.73	3.47	.30	.17	1.48	1.10	4.65	5.42	....	Brick clay	Ibid., p. 107.
Morganton, Burke County	60.05	67.03	16.88	6.50	1.00	1.16	.90	1.80	4.78	9.56	....	McDowell's yard	Do.
Grover, Cleveland County	36.55	53.07	29.54	1.27	.15	.14	2.15	1.29	9.93	4.71	Ferrous oxide, 1.00.	Pow. Clay. Mfg. Co., clay for white-face brick.	Ibid., p. 82.
Do	51.60	64.13	22.35	1.95	.10	.22	2.80	.95	5.98	5.07	....	Same company, pit ½ mile east of Grover.	Ibid., p. 83.
Do	39.05	61.75	23.30	3.34	.27	.25	1.31	1.18	7.75	5.67	Ferrous oxide, 0.50.	Underclay for red brick, Cleveland Brick Co.	Ibid., p. 108.
Do	51.45	65.45	20.02	4.18	.25	.29	1.51	.63	6.58	6.23	....	Upper clay, same company	Ibid., p. 109.
Fayetteville, Cumberland County	45.90	64.93	17.08	5.57	.43	.59	3.85	2.48	6.58	10.44	....	E. A. Poe's brick clay	Ibid., p. 110.

Do	52.15	58.17	20.10	7.48	.60	.77	2.60	3.23	7.34	11.40	....	So-called "tough clay," same yard.	Ibid., p. 111.
Bethania, Forsyth County	46.60	64.39	19.11	5.39	.80	.22	1.72	.90	7.75	8.13	....	Carter & Shepard, lower brick and tile clay.	Ibid., p. 112.
Do	32.78	55.81	20.06	11.79	.33	.16	1.42	1.85	8.80	13.70	....	Upper clay, Carter & Shepard	Do.
Mount Holly, Gaston County	49.05	61.28	20.83	5.51	.49	.14	.84	1.43	8.79	6.98	....	Not worked	Ibid., p. 113.
Greensboro, Guilford County	33.25	59.27	22.31	6.69	.25	.13	.90	1.90	9.00	7.97	....	Dean's brick clay	Ibid., p. 115.
Do	40.65	56.81	20.62	6.13	.65	.58	4.47	1.64	8.60	11.83	....	Greensboro Brick and Tile Co	Ibid., p. 114.
Do	64.92	69.70	12.87	6.13	2.55	.57	2.79	1.50	4.08	12.04	....	Kirkpatrick's brick clay	Ibid., p. 116.
Roanoke Rapids, Halifax County	57.08	67.55	13.16	8.54	.17	.28	2.65	1.63	5.08	11.64	....	Upper sandy brick clay	Ibid., p. 117.
Do	31.50	65.58	17.14	5.76	.72	.28	2.30	2.45	5.58	9.06	....	Middle brick clay	Do.
Do	39.82	59.68	16.09	8.91	1.35	.14	3.24	2.05	6.33	13.24	....	Under brick clay	Ibid., p. 118.
Spout Springs, Harnett County	40.90	64.16	21.76	1.58	.23	.15	.77	1.42	8.30	3.81	Ferrous oxide, 1.08.	Not worked	Ibid., p. 119.
Do	16.15	50.68	32.51	3.06	.30	.02	.58	1.35	11.08	3.96	....	.....do	Ibid., p. 120.
Do	26.65	53.65	28.66	4.50	.10	1.35	.29	1.05	10.79	6.24	....	.....do	Ibid., p. 121.
Sylva, Jackson County	52.25	66.70	19.75	3.25	.45	.16	2.12	.45	6.65	6.08	....	¾ mile south of station. Not worked.	Do.
Charlotte, Mecklenburg County	61.45	68.35	13.13	6.87	2.10	.32	2.82	1 35	5.30	12.15	....	D. K. Cecil's yard	Ibid., p. 123.
Do	39.50	59.15	18.36	6.04	.20	.34	1.72	7.10	7.47	8.30	....	F. W. Shuman's yard	Ibid., p. 124.
Do	56.45	65.95	14.67	7 61	2.57	.25	2.55	1.27	5.52	12.98	....	Sassamon's brick clay	Do.
Do	42.05	60.33	18.57	10 03	.20	.14	.55	.63	7 83	10.92	....	Upper clay, Asbury's yard	Ibid., p. 125.
Salisbury, Rowan County	51.90	69.89	15.31	4.39	.55	.16	.70	1.91	6 37	5.80	....	D. K. Cecil's yard	Ibid., p. 127.
4 miles north of Rockingham, Richmond county.	47.65	59.59	22 07	4.27	.65	.49	2.70	1.98	7 53	8.11	....	R. L. Steele's brick clay	Ibid., p. 126.
Red Springs, Robeson County	74.05	78.16	8.26	4.09	.40	.22	2.91	1.09	4.14	7.62	....	Sandy brick clay	Do.
Monroe, Union County	65.55	76.60	9.98	4.46	.30	.27	2.25	1.65	4.30	7.28	....	J. T. Shute's brick clay	Ibid., p. 129.
Raleigh, Wake County	54.55	70 03	15.64	2.88	.80	.57	1.47	1.60	6.37	5.72	....	Penitentiary clay pits	Ibid., p. 130.
Goldsboro, Wayne County	48.05	66.05	17.81	6.69	.30	.25	1.04	1.58	6.32	7.76	....	H. L. Grant's brick clay	Ibid., p. 132.
Do	54.15	67.90	18.74	3.16	.40	.45	1.85	1.85	6.03	5.86	....	Weil's clay pit	Ibid., p. 134.
Goldsboro, Wayne County	50.70	65.95	13.51	4.64	.35	.36	2.82	1.12	11.58	8.17	....	Grant's brickyard	Do.
Wilkesboro, Wilkes County	46.00	53.75	24.91	7.99	.70	1.12	2.94	1.03	7.60	12.75	....	D. Smoak's upper clay	Do.
Do	42.45	52.25	20.66	11.14	.60	1.08	4.62	2.10	7.45	17.44	....	D. Smoak's bottom clay	Ibid., p. 135.

Analyses of North Carolina clays—Continued.

BRICK CLAYS—Continued.

Locality.	Insol. residue.	Total silica.	Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Moist.	Water.	Total fluxes.	Miscellaneous.	Remarks.	Firm name, authority, or analyst.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
Wilson, Wilson County	43.25	62.99	13.56	11.52	0.10	0.29	2.07	2.31	6.03	14.31	Ferrous oxide, 0.33	Red-top clay, Lucas's south pit	Ibid., p. 136.
Do	51.75	68.90	14.36	6.04	.03	.31	2.30	1.70	5.83	8.68		Blue clay, Lucas's north pit	Ibid., p. 137.
Do	53.55	68.28	13.59	5.66	.15	.47	1.41	1.68	6.00	7.69		Lucas's new yard	Ibid., p. 138.
POTTERY CLAYS.													
Morganton, Burke County	54.28	69.58	14.03	6.41	0.10	0.27	1.65	1.68	5.73	8.73		McDowell's property	Bull. 13, N. C. Geol. Surv., p. 75.
Northwest of Blackburn, Catawba County.	26.05	50.17	28.77	2.88	.05	.22	1.04	2.08	[a]14.03	4.19		Used for stoneware	Ibid., p. 76.
Two miles northwest of Lincolnton, Lincoln County.	36.57	57.20	24.82	3.25	.73	.13	.93	2.10	8.25	6.46	Ferrous oxide, 1.42	Stoneware clay	Ibid., p. 77.
Do	35.96	57.08	26.11	4.64	.20	.16	1.42	.69	8.52	6.42		do	Ibid., p. 78.
Wilkesboro, Wilkes County	24.00	54.38	27.27	5.48	.45	.41	.68	1.28	9.78	7.02		do	Do.
Do	32.35	54.24	24.97	4.83	.57	.70	2.52	2.20	9.40	8.62		C. Cowles's property, not worked	Ibid., p. 79.
PIPE CLAYS.													
Pomona, Guilford County	33.40	58.73	23.94	3.71	0.05	0.09	1.25	1.53	9.80	5.10		Upper pipe clay, first pit. Pomona Terra Cotta Co.	Bull. 13, N. C. Geol. Surv., p. 89.
Do	32.51	54.28	22.27	8.45	.45	.18	.60	2.05	[a]10.50	11.01	Ferrous oxide, 1.33	do	Do.
Do	59.70	70.75	13.87	5.01	.82	.29	1.15	2.20	5.00	7.27		Pipe clay, second pit. Pomona Terra Cotta Co.	Ibid., p. 90.

[a] Including organic matter.

FIRE CLAYS.

Grover, Cleveland County	53.30	68.28	18.83	2.60	0.70	0.13	2.29	0.76	6.47	5.72	Titanic acid, 0.27	Eskridge's pit	Bull. 13, N. C. Geol. Surv., p. 81.
Pomona, Guilford County	51.50	70.45	17.34	3.16	.25	.22	.70	.98	6.63	4.66	Ferrous oxide, 0.33	First pit. Pomona Terra Cotta Co.	Ibid., p. 84.
One mile north of Pomona, Guilford County.	56.70	71.60	15.27	3.33	.17	.21	2.12	1.43	5.40	5.83	....	Woodroff's clay bank	Ibid., p. 85.

MISCELLANEOUS ANALYSES.

The following analyses of clay from different States have been received at this office during the past year:

Analyses of clays from various localities in the United States.

Locality.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Alkalies.	Moist.	H_2O on ignition.	Miscellaneous.	Remarks.	Uses.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
Colorado:											
Golden, Jefferson County	39.134	33.64	.75	....	Trace.	.58	3.13	11.75	TiO_2, .80. Qtz., 11.216. Clay subs., 84.524.	Mon. XXVII U. S. G. S., p. 390.	Crucibles.
Kentucky:											
Olive Hill, Carter County	43.76	40.21	.53	.88	.06	....	....	14.56	....		
Illinois:											
Streator, La Salle County	61.76	18.32	7.04	....	1.45	3.49	....	7.94	....	Barr Clay Co	Brick.
Indiana:											
Indianapolis, Marion County	59.08	31.30	.50	.80	.60	....	....	7.72	....	Indianapolis Terra Cotta Co.	Terra cotta.
Ohio:											
Doughton, Trumbull County	63.69	23.91	3.57	.44	Trace.	....	....	8.36	....	Semiplastic blue-gray clay.	
Do	62.86	23.91	9.21	.34	.48	....	....	6.26	....	Yellow clay.	
Do	66.28	21.49	3.21	Trace.	5.75	....	....	5.85	....	Plastic, whitish gray.	
Minnesota:											
Hutchinson, McLeod County	48.25	36.60		[a] 1.49	[a] .70	....	....	8.50	Org. mat., etc. 4.46.	M. C. Madsden.	
Minneapolis, Hennepin County	60.31	23.77	7.96	2.50	1.75	2.42	....	....	....	A. Humphreys.	
Ottawa, Lesueur County	59.72	30.00	....	.82	.51	....	....	10.34	....	Ottawa Brick Co.	
Missouri:											
St. Louis, St. Louis County	60.31	23.52	2.57	Trace.	.90	.59	1.96	10.11	....	Christy Fire Clay Co	Washed clay for glass pots.
Pennsylvania:											
Butler, Butler County	59.01	21.77	10.73	.79	1.69	6.01	....	....	....	Butler Brick and Tile Co.	
Texas:											
San Antonio, Bexar County	69.48	20.99	1.02	....	....	1.20	....	7.22	....	San Antonio Sewer Pipe and Manufacturing Co.	
Virginia:											
Robious, Chesterfield County	80.76	11.004	1.396	.504	.108	.832	....	5.025	....	J. R. Jackson.	
Wisconsin:											
Hersey, St. Croix County	58.82	31.18	Trace.	.07	.05	.38	....	10.04	....	Superior China Clay Co	Crude kaolin.
Do	49.70	38.25	.05	Trace.	Trace.	.37	....	12.00	....	do	Washed material.

[a] Carbonate of lime.

CEMENT.

PORTLAND CEMENT.

By Spencer B. Newberry.

PRODUCTION.

The product of Portland cement in the United States in 1897 amounted to 2,677,775 barrels, an increase of 1,134,752 barrels, or nearly 74 per cent, over the product of 1896. This remarkable growth is distributed fairly evenly over all producing districts, but is most marked in the Lehigh Valley region, in Pennsylvania. In this section, which produces most of the Portland cement made in this country, the product in 1897 was nearly double that of the preceding year.

The following table shows the product of Portland cement in the United States in 1896 and 1897, by States:

Product of Portland cement in the United States in 1896 and 1897.

State.	1896.			1897.		
	Number of works.	Product.	Value, not including packages.	Number of works.	Product.	Value, not including packages.
		Barrels.			*Barrels.*	
Arkansas				1	15,000	$26,250
California	1	9,000	$18,000	1	15,000	30,000
South Dakota	1	24,000	48,000	1	39,890	79,780
Illinois	1	3,000	5,250	1	15,000	26,250
Indiana	1	9,000	15,750	1	2,823	2,117
Michigan	1	4,000	7,000	2	15,000	26,250
New York	7	260,787	443,175	7	394,398	690,197
New Jersey	2	247,100	370,650	2	430,335	753,086
Ohio	4	153,082	267,892	4	146,452	256,291
Pennsylvania	7	825,054	1,224,294	7	1,579,724	2,369,586
Texas	1	8,000	24,000	1	7,778	23,334
Utah				1	16,375	32,750
Total	26	1,543,023	2,424,011	29	2,677,775	4,315,891

This table shows that three new factories, one in Arkansas, Utah, and Michigan, respectively, have contributed slightly to the increased production. Ohio shows a moderate decrease, owing to the destruction by fire of the works at Middle Branch. The production of the one small factory in Indiana is also much reduced. Other sections, especially New York, New Jersey, and southeastern Pennsylvania, show an immense gain. As noted in last year's report, the chief seat of the Portland cement industry remains in the eastern part of the country, and the Central, Western, and Southern States make, as yet, but a meager showing.

The relative development of the industry in different sections of the United States since 1890 is shown in the following table:

Table showing development of Portland cement industry in the United States since 1890.

Section.	1890.			1894.			1897.		
	Number of works.	Product.	Per cent.	Number of works.	Product.	Per cent.	Number of works.	Product.	Per cent.
		Barrels.			*Barrels.*			*Barrels.*	
New York	4	65,000	19.4	4	117,275	14.7	7	394,398	14.7
Lehigh County, Pa., and Phillipsburg, N. J.	5	201,000	60.0	7	485,329	60.8	8	2,002,059	74.8
Ohio	2	22,000	6.5	4	80,653	10.1	4	146,452	5.5
All other sections	5	47,500	14.1	9	115,500	14.4	10	134,866	5.0
Total	16	335,500	100.0	24	798,757	100.0	29	2,677,775	100.0

This table shows that the production in the neighborhood of Lehigh County, Pennsylvania, has increased in seven years to nearly ten times what it was in 1890, and that nearly three-fourths of the Portland cement made in the United States is now produced in that section. The increase in other parts of the country has been very slow, and has by no means kept pace with the increased consumption of cement in the same sections. Apart from the great producing region of Lehigh County, Pennsylvania, the Portland-cement industry of the United States is still insignificant.

IMPORTS.

The imports of Portland cement in 1897 were 2,090,924 barrels of 400 pounds each, a decrease of 898,673 barrels from those of the preceding year. The cause of this decrease is to be found in the gradual replacement of foreign by domestic Portland cement, and also in the marked stagnation in building industries which prevailed during the first half of the year. Foreign manufacturers find also a ready and constantly increasing demand for their product in their home market, and are much less active than in former years in attempting to extend their trade in this country. The magnitude of the Portland-cement industry in Germany is shown by the reports of the Association of German Portland Cement Manufacturers. This association included, in February, 1898, representatives of 66 German factories, the total production of which amounts to 15,000,000 barrels per year. In 1893 the production amounted to only 11,500,000 barrels. An increase of 3,500,000 barrels has therefore taken place in the last five years. By far the larger part of this increased product is consumed in Germany itself. Reports made by leading German engineers show that other hydraulic materials are but little used in that country, Portland cement having proved cheaper in use, even for the commonest purposes.

The following table shows the imports, by countries, in 1896 and 1897:

Imports of cement into the United States in 1896 and 1897, by countries.

[Barrels.]

Country.	1896.	1897.
United Kingdom	742,169	344,336
Belgium	742,237	529,686
France	26,714	19,319
Germany	1.366,909	1,109,280
Other Europe	99,184	46,916
British North America	11,334	4,907
Other countries	1,050	36,480
Total	2,989,597	2.090,924

This table shows that the imports from Germany have decreased much less than those from other countries. While in 1896 the imports from Germany were 45 per cent of the total, in 1897 this proportion had risen to 53 per cent. The imports from Great Britain in 1897 were less than one-half those of 1896, and are now comparatively insignificant. English Portland cement is, in fact, seldom met with in our principal cities at the present time.

Trade reports toward the close of the year showed that the demand for Portland cement in Europe was far beyond the supply. Manufacturers were far behind on orders and prices had advanced considerably. This condition of affairs was still more marked early in 1898. At present American importers of European cement find great difficulty in securing an adequate supply to complete their contracts, and are making but little effort to meet the competition of domestic Portland. The prejudice which once existed against the American product may be said to have entirely disappeared, and foreign and domestic cements compete on nearly even terms on the basis of price and quality. These conditions make it appear probable that the year 1898 will witness a still further falling off in imports, and that the complete replacement of foreign by domestic Portland cement is not far distant.

The above table shows that Belgium comes next after Germany in amount of cement exported to the United States. The imports from Belgium in 1897 show a considerable decrease from those of the preceding year, but have advanced rapidly during the last few years. Most of the Belgian product is of distinctly inferior grade, and is not, properly speaking, a true Portland cement, since it is produced by burning a natural cement rock in its raw state. At the last meeting of the Association of German Portland Cement Manufacturers Dr. Prussing reported on the unfair competition of the "natural Portland cements" of Belgium against the true artificial Portland cement of Germany. These Belgian cements are chiefly made by the direct burning of a limestone of approximately the composition of a correct cement mixture. The variations in the proportions of lime and clay present in the rock, however, cause great fluctuations in the quality of the product, and many of the Belgian manufacturers sell their product under foreign labels as Portland cement of highest quality, and in many cases well-known German labels are purposely counterfeited.

At a meeting of English and German cement manufacturers held in Cologne in July, 1897, it was resolved to take the following steps to meet this fraudulent competition:

1. Samples of Belgian natural cement are to be purchased in open market and tested at the royal testing station at Charlottenburg, and by competent experts in England.
2. An attempt is to be made to secure from the Belgian Government an official definition of Portland cement.
3. A pamphlet is to be published showing the untrustworthiness of the so-called Belgian "natural Portland cements," and stating the names of the Belgian factories which produce a genuine and reliable article. This pamphlet is to appear in German, English, French, and other languages, and is to be circulated as widely as possible in all countries.

RELATION OF DOMESTIC PRODUCTION TO IMPORTATION.

The total consumption of Portland cement in the United States increased in the five years ending with 1896 by about 1,000,000 barrels. The increased consumption in 1897 over that of 1896 was 268,099 barrels. The comparatively small amount of this increase is due to the great inactivity in building operations which prevailed during the first half of the year. Owing to the great increase in domestic production and the marked decrease of imports, the proportion of domestic to imported cement consumed evinces a remarkable advance, as the following table shows:

Comparison of the domestic production of Portland cement with the imports.

[Barrels.]

	1891.	1895.	1896.	1897.
Production in the United States	454,813	990,324	1,543,023	2,677,775
Imports	2,988,313	2,997,395	2,989,597	2,090,924
Total	3,443,126	3,987,719	4,532,620	4,768,699
Exports	....	83,682	85,486	53,466
Total consumption	3,443,126	3,904,037	4,447,134	4,715,233
Percentage of total consumption produced in the United States	13.2	25.4	34.7	56.8

In the above table the exports shown under the years 1895 and 1896 consisted of both cement and lime. These items are now separately classified by the Treasury Department, and the figures for 1897 represent cement only.

The above table shows that during the last year the increase in the domestic production of Portland cement has, for the first time in the history of the industry in this country, greatly exceeded the increase in consumption. Considerably more than half the Portland cement consumed in 1897 was of American manufacture. This important step toward the replacement of imported by domestic Portland has been largely brought about by the successful efforts of American manufacturers to produce a high-grade product. Engineers in all parts of the country are finding, to their surprise, that the product of the leading American factories shows decidedly higher tests than the imported brands which have long been regarded as a standard. This is strikingly shown in the reports of Mr. Richard L. Humphrey, inspector of cements for the city of Philadelphia. These reports are included in the annual messages of the mayor of Philadelphia. The average of all American Portlands tested in 1896 and 1897 is decidedly higher, both neat and with sand, than that of all the English or German Portlands tested. In fineness of grinding also the American cements were found superior to the imported. It is gratifying to find that an industry so new to this country, and one requiring so high a degree of technical knowledge, has already been developed to a point beyond that which it has reached in England and Germany.

The conditions which have influenced the American Portland-cement industry in 1897 appear likely to prevail in a still more marked degree in 1898. The war with Spain has led to an immense amount of work on seacoast fortifications, and has brought the United States Government into the market as a purchaser to the extent of thousands of barrels of Portland cement per day. Building enterprises have also been very active during the early months of the year. Imports during the same period show a considerable increase over 1897. The present year will undoubtedly show a further increase in production. The two largest factories in the country, situated at Coplay, Pennsylvania, and Phillipsburg, New Jersey, respectively, are increasing their capacity by nearly 50 per cent, and at many other works extensive enlargements are in progress. Many new enterprises are projected, but those in all sections, except the East, seem to be slow in materializing. From present indications it appears probable that the American production in 1898 will reach 3,500,000 barrels, and that the Lehigh Valley region will produce a still larger proportion of the total than in 1897.

THE PORTLAND-CEMENT INDUSTRY IN THE VARIOUS STATES.

California.—Works are to be built at Arroyo Grande.

Connecticut.—A factory has been established at Stamford by the Berkshire Portland Cement Company. Marl from the Berkshire hills and clay from Long Island are the raw materials. As the deposits from which these are obtained are nearly 200 miles apart, and both must be transported to Stamford, the enterprise will certainly labor under considerable disadvantage.

Illinois.—The factory of the Chicago Portland Cement Company was destroyed by fire February 3, 1898. The work of rebuilding was at once begun, and it is stated that the new works will be on a much more extensive scale than the former ones. Limestone from Bedford, Indiana, is the principal raw material.

Indiana.—The works of the St. Joe Portland Cement Company, at South Bend, have been purchased by the C. H. Rose Company, of Chicago, and are to be greatly enlarged.

A large deposit of marl at Syracuse, Kosciusko County, has been purchased by the Sandusky Portland Cement Company, of Sandusky, Ohio. The deposit covers an area of over 400 acres, and is from 20 to 40 feet in depth. It is estimated by the purchasers that the amount of material available is sufficient to produce 2,000 barrels of cement per day for seventy-five years. Clay of suitable quality is found in close proximity to the marl.

Analysis of this marl resulted as follows:

Analysis of marl from Syracuse, Kosciusko County, Indiana.

	Per cent.
Calcium carbonate	88.49
Magnesium carbonate	2.71
Insoluble	1.78
Iron oxide and alumina	1.21
Calcium sulphate	1.58
Organic matter, etc., by difference	4.23
Total	100.00

This marl shows a much lower proportion of magnesia than has been generally found in the marls of Indiana and southern Michigan. It is the intention of the Sandusky company to begin at once the erection of large works at this point.

Michigan.—The works of the Monarch Portland Cement Company, at Bronson, were started late in the year. Extensive additions are already projected. A deposit of marl has been found near Coldwater, and works at that point are in process of erection.

Ohio.—The plant at Middle Branch, destroyed by fire early in 1897, is being rebuilt on a more extensive scale.

The works of the Sandusky Portland Cement Company, at Bay Bridge, near Sandusky, have been enlarged to a regular production of 500 barrels of cement per day.

The Castalia Portland Cement Company began the construction of works near Sandusky in the fall of 1897, and expect to produce cement in the summer of 1898. The material used is a white marl, which covers a part of the Castalia prairie, and appears to have been deposited from the water of the Castalia springs. The rotary process of burning will be used.

Pennsylvania.—New works are in process of construction by the Lehigh Portland Cement Company and the Nazareth Portland Cement Company, near Allentown, and also at Maidencreek, Berks County. These will all use argillaceous limestone from the same formation as that employed at Coplay. The Atlas Cement Company is again largely increasing its works. The Clinton Cement Company, of Pittsburg, is building works, and will make Portland cement by burning a mixture of limestone and blast-furnace slag.

MATERIALS.

By far the larger part of the Portland cement product of the country is still made from limestone, as the following table shows.

Comparative product of Portland cement from limestone and marl.

	1896.		1897.	
	Number.	Product.	Number.	Product.
		Barrels.		*Barrels.*
Factories using limestone	18	1, 208, 234	18	2, 282, 126
Factories using marl	8	334, 789	11	395, 649
Total	26	1, 543, 023	29	2, 677, 775

PROCESSES.

The use of the rotary kiln continues to increase, as the following table shows.

Amount of Portland cement made in kilns of various kinds.

[Barrels.]

	1893.	1895.	1896.	1897.
Rotary kilns	149, 000	400, 821	632, 370	1, 311, 319
Vertical kilns (continuous and intermittent)	441, 653	589, 503	910, 653	1, 366, 456
Total	590, 653	990, 324	1, 543, 023	2, 677, 775
Per cent of total product burned in rotary kilns	25. 2	40. 5	41. 0	49. 0

AMERICAN ROCK CEMENT.

By Uriah Cummings.

PRODUCTION AND PRICE.

The production of rock cement in the United States during the year 1897 was the largest ever known in the history of the industry. There were 8,311,688 barrels placed upon the market, being an increase of 341,238 barrels over the output for 1896, or 4.28 per cent.

Active competition among the manufacturers, due mostly to the fact that the capacity exceeds the demand by about 25 per cent, has had a tendency to depress the prices somewhat.

The following table gives the amount and value of the rock cement produced in the United States during 1896 and 1897. The values are based on the selling prices in bulk at mills.

Product of rock cement in 1896 and 1897.

State.	1896.			1897.		
	Number of works.	Product.	Value.	Number of works.	Product.	Value.
		Barrels.			*Barrels.*	
Georgia	1	12,700	$9,525	1	18,165	$10,899
Illinois	2	544,326	217,731	3	510,000	209,000
Indiana and Kentucky	15	1,636,000	654,400	15	1,731,287	692,515
Kansas	2	125,567	50,226	2	160,000	64,000
Maryland and West Virginia	5	271,500	125,175	5	296,000	118,400
Minnesota	2	83,098	38,549	2	111,731	55,865
New York	29	4,181,918	2,423,891	29	4,259,186	2,123,771
Ohio	3	28,565	17,139	3	23,697	14,218
Pennsylvania	6	608,000	304,000	7	775,000	387,500
Texas	1	12,000	18,000	1	11,390	17,085
Virginia	3	16,776	10,566	3	15,232	9,139
Wisconsin	1	450,000	180,000	1	400,000	160,000
Total	70	7,970,450	4,049,202	72	8,311,688	3,862,392

NEW DEVELOPMENTS.

The two cement works at Howes Cave, New York, have passed into the hands of a single company, and the works are being enlarged and improved with new buildings and machinery.

In the Louisville, Kentucky, district, two new plants of large capacity are being erected, with the expectation of getting their products upon the market during the season of 1898.

PRECIOUS STONES.

By George F. Kunz.

PRINCIPAL DEVELOPMENTS OF THE YEAR.

The principal items of interest in the gem line during 1897 were (1) the investment of English capital and the increased output of the sapphire deposits in Yogo Gulch, Fergus County, Montana; (2) the further development of the turquoise in Santa Fe and Grant counties, New Mexico, and the discovery of new localities in Arizona, California, and Nevada, and the increased development of tourmaline deposits at Mount Mica, Paris, Maine, and at Haddam Neck, Connecticut; (3) the finding and sale of the pale almandine garnets from the Cowee Valley, North Carolina; (4) the finding of large quantities of gigantic quartz crystals (rock crystal) at Mokelumne Hill, Calaveras County, California; (5) the sale of the rondelle and ovoid form of gems, and rondelle and ovoid gems combined; (6) the greater importation of diamonds immediately upon the change of import tariff from 25 to 10 per cent; and (7) the continued increase of popularity of Australian opals.

DIAMOND.

SOUTH AFRICAN FIELDS.

The development of the South African diamond fields is the most important feature of the rough diamond trade of the world; therefore the details of the operations of the great company which practically controls these mines are of general interest. From the admirable annual report for 1897 of Mr. Gardner F. Williams, manager of the De Beers Consolidated Mines, Limited, the following statement is taken:

Statement of the operations of the De Beers Consolidated Mines, Limited.

	£	s.	d.
Balance carried forward on the 30th of June, 1897, after providing for the payment of dividends of 20 per cent each	683,047	17	11

	£	s.	d.	£	s.	d.
During the twelve months, as will be seen from the accompanying statements, the diamonds produced realized				3,722,099	3	3
Total expenditure, including amount written off for machinery and plant account, etc	175,523	14	7			
And payment of interest on the company's debentures and obligations	183,415	3	6			
				1,689,537	17	3
Leaving a profit of				2,032,561	6	0

The profit and loss account stands as follows:

	£	s.	d.	£	s.	d.
Balance as above				2,032,561	6	0
Dividends on investments and rents				18,992	3	8
Revenue from various sources				2,085	6	11
Balance from last year	329,356	10	2			
Less life governors' remuneration paid	120,365	8	10			
				208,991	1	4
				2,262,629	17	11
Dividends paid and provided for				1,579,582	0	0
Balance carried forward to next year				683,047	17	11
				2,262,629	17	11

The average yield per load for De Beers and Kimberley was	0.92 carat.
The average value per carat for De Beers and Kimberley was	26s. 10.6d.
The average value per load for De Beers and Kimberley was	24s. 8.6d.

The reserve fund invested in English consols, which on June 20, 1896, stood at £1,118,172, has been increased during the year by the addition of accrued interest, and now stands at £1,148,133, nominal value £1,150,000; present market value (at £112) £1,288,000.

Work has been done in the De Beers on a level as low as 1,520 feet, 5,131 loads being taken from the 1,200-foot level in twelve hours.

In the following table is given a statement of the output from the De Beers and Kimberley mines in 1896 and 1897:

Output from the De Beers and Kimberley mines during the years ending June 30, 1896 and 1897.

	1896.	1897.
Blue earth hoisted (loads of 16 cubic feet)	2,698,109	2,515,889
Blue earth washed (loads of 16 cubic feet)	2,597,026	3,011,288
Average yield, in carats, per load	0.91	0.92
Cost of washing and winning	7s. 1d.	7s. 4.3d.

The comparative areas in acres of the open works of the mines for the years 1890, 1894, and 1897 are as follows:

Surface areas of the open works of the mines.

Year.	De Beers.	Kimberley.	Premier.	Dutoitspan.	Bulfontein.
1890	18.68	31	....	35.05	27
1894	21.50	33	14	44.25	36
1897	30.00	38	24.5	47	40.5

In the following table is given a statement showing the average number of persons daily employed in the South African diamond mines:

Number of employees in the South African diamond mines.

	Above ground		Underground.		Total, including salaried staff.	
	Whites.	Blacks.	Whites.	Blacks.	Whites.	Blacks.
De Beers	477	1,851	219	2,001	696	3,852
Kimberley	187	925	183	1,322	370	2,247
Premier	46	423	105	489	151	912
Workshops	388	211			388	211
On estates and elsewhere	28	118			28	118
Total	1,126	3,528	507	3,812	1,633	7,340

Nationalities of white employees.

	In and about the mines and floors.		At the workshops.	
	January, 1894.	January, 1897.	January, 1894.	January, 1897.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
English	52.2	46.5	41.5	37.1
Scotch	6.2	7.2	23.3	20.6
Irish	4.8	5.6	2.4	2.8
South Africans	33.1	36.8	27.1	33.3
Europeans	1.8	1.5	4.2	4.7
Other nations	1.9	2.4	1.5	1.5
Total	100	100	100	100

AUTOMATIC SORTER.

While experimenting to find some mechanical means of separating diamonds from the heavy deposit, Messrs. Labram and Kirsten, employees of the De Beers Company, discovered that a shaking table with a rapid side motion, when covered with grease of a certain consistency, holds the diamonds, while all other minerals of which the deposit is composed flow over the grease to the end of the table. So far experiments have been made with a small machine only, but the results are so favorable that a number of large machines are being constructed with the view of doing all the sorting mechanically.

Prof. L. De Launay, in a recent work,[1] gives an excellent résumé of the occurrence and production of diamonds in South Africa, bringing the subject up to date.

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[1] Les diamants du Cap, Paris, 1897, 226 pp., 8°, illustrated.

NEW DIAMOND POLISHING TOOL.

There has been recently patented by Messrs. Stern Bros., of New York, a new diamond polishing tool. It consists of a stationary section with a segmental recess, fitted in which is a segmental plate with an eccentric slot adjustable to any angle. Integral to this segmental plate is a specially constructed chuck, which consists of three metallic gripping fingers and a rotary base upon which rests the diamond. The gripping fingers are independently adjustable, and fit themselves to a stone of any size or shape, holding it securely in the adjusted position, and permitting the polisher to have full view of the stone at all times.

The advantages possessed by this tool over those of the former primitive method, in which the diamond is held in a mass of lead or a brass cup or dop, are apparent. By its use there is less danger of injuring the diamond through an error in setting or miscalculation as to the extent of surface polished, and through flawing from the repeated dippings in cold water when it is soldered in the metal and from the repeated heatings by the old process, often twenty or more times. It also does away with the necessity of the services of the setter or workman who sets the stones in the leaden dop.

GENESIS OF THE DIAMOND.

Dr. George F. Becker, of the United States Geological Survey, has published in Science[1] a criticism[2] in which he maintains that the origin of the South African diamonds is not due to the distillation of the shale, but that they are as much a part of the original rock as are the biotite, garnet, titanic and chromic iron, and perovskite, and have come up from below.

Bearing on the genesis of the diamond, an article from the pen of Prof. T. G. Bonney has appeared in the Geological Magazine,[3] describing some rock specimens from Kimberley, South Africa, in which he presents his conclusions in regard to the origin of the diamonds and the volcanic phenomena of the region. He concludes that, as he formerly stated, the diamonds were not produced where they are now discovered, but, like the conspicuous olivine, pyroxenes, mica, garnets, and iron oxides, had their origin at a much greater depth in the earth's crust, and that it is improbable that the carbon was obtained from the Karoo shales. In other words, he considers the diamonds, whatever may have been their previous history, to have come from the crystalline floor on which these shales were deposited, or to be, at any rate, pre-Triassic in age, and sees no reason why carbon should not be present in the earth's magma, whether it afterwards crystallized in a peridotite or in native iron.

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[1] October 29, 1897, new series, Vol. VI, No. 148, pp. 664-667.

[2] Precious stones, "Genesis of the diamond": Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (continued), Mineral Resources, 1896, pp. 1191-1196.

[3] On somerock specimens from Kimberley, South Africa: Geol. Mag., London, October and November, 1897, new series, Decade IV, Vol. IV, pp. 448-453, 497-502.

Volcanic action probably began before the end of the Karoo epoch, as the great sheet of so-called melaphyre seems to be intercalated with its higher deposits, and some of the dikes may be approximately coeval with it. Afterwards (was it because of this impenetrable cover of lava?) the pipes were formed, probably in a short time, by a series of great explosions, caused by gases accumulated at considerable depth. These sent the outer part of the crystalline floor, including diamonds as well as the overlying Karoo shales, flying shattered into the air. Cones and craters may have been built above these pipes, but he believes that, like some of those in the Eifel, they were never high, and that most of the shattered material, after a few explosions, fell back into the pipes and filled them, like the "necks" in Scotland. Then the volcano, after more lava had struggled to reach the surface (forming, at any rate, the dikes in the necks), passed into a solfatara stage, during which the numerous secondary changes mentioned above were produced, the carbonates were deposited, and the minor structure of the mass was obscured. Afterwards ordinary meteoric agencies began to work; water percolating from above still further affected the mass, more especially in its upper parts, producing the "yellow ground" and the "soft blue," and depositing tufa.

The result of this examination is to confirm Professor Bonney in his opinion that the diamantiferous rock—the so-called kimberlite—is a volcanic breccia rather than a peculiar form of peridotite. While it is difficult, owing to secondary changes, to demonstrate the fragmental character of the matrix, he had failed to identify it with any form of peridotite (or serpentine) known to him, and he did not understand how masses of that rock, the smallest of which is about 370 yards in diameter, and one of which has been traced to a depth of 500 yards, could remain throughout in a practically uniform glassy condition.

In June last, in connection with the "Diamond Jubilee" of Queen Victoria, a lecture on diamonds was delivered at the Royal Institute, London, by the eminent physicist Dr. William Crookes, F. R. S. This lecture[1] has sufficient importance to be referred to here, inasmuch as it gives the latest views regarding the origin of diamonds of one who stands in the front rank of living physicists, and who has himself lately visited and examined the diamond mines at Kimberley. Dr. Crookes treated of the different forms of graphite, and their relations to diamond-carbon and of the combustion of diamonds and graphites and of their specific gravities. The fact is emphasized that while, being isometric, diamonds should have no action on polarized light, they frequently do affect it, thereby indicating a condition of high internal strain. Indeed, of the hundreds of crystals which he has examined under polarized light Dr. Crookes has found this to be true with few exceptions. In this connection also the frequent breaking, or even "explosion," of crystals after being brought to the surface is noted. This is not noted as being the case after cutting.

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[1] Published in the Journal of the Institute, Vol. V, 1897; also in Nature for August 5, 1897, Vol. LVI, pp. 325–331.

The optical properties of the diamond were next dealt with—its refracting and reflecting brilliancy and its phosphorescence and fluorescence; its extreme transparency to Röntgen rays; and its partial conversion into graphite by the heat of a bombardment by radiant matter in a vacuum tube under a very powerful current.

As to the genesis of diamond, Dr. Crookes fully believes that Moissan's artificial method is a reproduction of the process in nature. Carbon volatilizes at about 3,600° C., or 3,874° absolute, without fusing; but by analogy with other volatilizing solids, under sufficient pressure at that temperature, it would liquefy. Calculating the pressure necessary for carbon, he fixes it at about 2,300 atmospheres, or 15 tons on the square inch—an amount not difficult to obtain, as temperatures of 4,000° C. and pressures of 95 tons have been reached in steel cylinders. Dr. Crookes here repeated Moissan's process before the audience, explaining it in detail, and then went on to say that, in his view, the African diamonds were not formed in situ in the "pipes," but were brought up from great depths, where the heat and pressure had been adequate to their production in some closely similar manner. He recalled the optical evidences of strain in the crystals and their frequent bursting apart, and emphasized the occurrence of many broken crystals and fragments in the "blue ground" as favoring this view.

It is clear, he claims, that the "pipes" are not ordinary igneous outbursts. The inclosing walls show no indications of such action. The pipes, after they were pierced, were filled from below, and the diamonds formed at some previous epoch were erupted with a mud volcano, together with all kinds of débris eroded from the adjacent rocks, forming "a geological plum pudding of heterogeneous character," which "has suffered no great heat in its present condition." He conceives each pipe as a conduit leading to a deep-seated mass of iron, at enormous pressure and temperature, in which carbon was liquid in the form of drops that, alone or coalescing, formed large and small, single or twin, crystals or rounded masses of bort and carbonado. Water, on reaching the depths through fissures, developed vast volumes of steam, and hydrogen by contact with the heated iron. These gases then forced their way to the surface, opening the conduits or pipes; as in certain experiments with gunpowder and cordite in closed steel cylinders, if there be a small orifice the escaping gases will erode an open channel almost instantaneously through plugs of steel or of granite. The opening thus made would then be filled by an outflow of mixed materials—"rocks, minerals, iron oxide, shale, petroleum, and diamonds, in a veritable witch's cauldron"—borne upward by a rush of steam and later of hot water. Each outbreak would form a rounded hill, subsequently removed by erosion.

Such is Dr. Crookes's theory, a very ingenious and brilliant one, from a man of great eminence in physics. It will be seen that it differs very widely from the views of the late Prof. Carvill Lewis, as summarized in Mineral Resources last year[1] and is more in accord with those of Professor Bonney previously referred to. Professor Lewis dealt more with the geological and mineralogical aspects, as Dr. Crookes naturally does with the chemical and physical. To discuss the points of difference between them would be out of place here. In concluding, the occurrence of diamonds in meteorites was treated of, the "meteoric theory" of their origin being very fairly estimated as only an occasional and interesting incident, one of many facts indicating similarity of conditions and combinations in the earth and other bodies in space.

BLEACHING OF SPOTTED DIAMONDS.

The value of diamonds is frequently affected by their containing specks of various form and color, termed "flaws." When a diamond is filled with them it possesses value only for industrial purposes. Cohen pronounced these inclusions oxide of iron. Maillard, a jeweler of Paris, is said to have succeeded two hundred years ago in destroying black spots within a diamond by heating the stone to red heat, excluding the air during the heating.

Mr. Henri Moissan states that the spots are a carbon product, and he succeeded in eradicating them, but by a process not available for commercial purposes, for in removing the spot the diamond was also destroyed. A black diamond with transparent spaces was resolved into a fine dark-gray powder, the particles of which still contained a number of specks as seen under the microscope. This powder he placed in a tube heated to a little less than red heat, and oxygen was then allowed to pass through it for half an hour. It was evident, by the examination of the oxygen issuing from the tube, that carbonic acid was formed and absorbed by the oxygen. After cooling off, the diamond powder in the tube was found to be absolutely white, and no more flaws were visible even under the microscope. The chemical process appears to be a dissolution of the black substance contained in the diamond by the oxygen, forming carbonic acid. Small diamonds were not affected by this treatment, but Moissan believes that the bleaching of spots within diamonds will also be possible by employing oxygen under great pressure, which would penetrate into the diamond. If this is successful, it will be the means of enhancing in value many stones now cheap on account of flaws, although the success is problematical except in minute stones.

CORUNDUM.

Mr. Elfric Drew Ingall, M. E., says[2] that corundum is known to occur in Canada, but so far the deposits have not been worked, and there is therefore nothing to report in the way of either that material or the granular form known as emery. Recently extensive discoveries of corundum have been made in Hastings and Renfrew counties in eastern Ontario, along a belt of country varying from 1½ to 3 miles in width, extending from the German settlement south of the village of Rockingham, in the township of Brudenell, for about 16 miles west-southwest into the township of Carlow. The mineral occurs as a very important and, at times, abundant constituent in pegmatite, cutting biotite-granite-gneiss; in a very felspathic granite or syenite-gneiss, and in a light-gray or whitish albite-gneiss and nepheline-syenite. It is also sparingly present in small crystals disseminated through the more felspathic bands of the ordinary biotite-gneiss, but seems to be rarely, if ever, present in the dark-colored basic portions interbanded with these rocks. Over certain limited areas the mineral is more concentrated, in many instances constituting from 30 to 60 per cent of the rock mass. Some of the deposits at present known, especially those in the northwestern part of Raglan, are easy of access. Later reports state that large crystals have been found and that corundum exists as plentifully as in the North Carolina and Georgia regions.

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[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (continued), 1896, pp. 1191-1196.

[2] Geol. Nat. Hist. Survey Canada, Ann. Rept., Vol. IX, Part S, p. 15.

TURQUOISE.

Turquoise has long been known to exist in Nevada, but not of gem quality. However, announcement has recently been made of the discovery of material of good quality in Lincoln County, at the base of Sugar Loaf Peak. The turquoise occurs principally in a large dike of igneous rock (its particular character is not stated), which cuts through a gneiss that forms the country rock. This dike is about 250 feet wide, and is plainly traceable for nearly a mile. As in New Mexico, stone implements and old workings are round, the latter filled up and observable only by the sinking in of the loose filling and the fragments of turquoise contained in it. Work has been begun here, several openings having been made, with two cross-cuts, and a shaft 25 feet deep. Stones from this locality have been sold in Denver, Los Angeles, and New York. The largest one reported weighed 64 carats, others 10 to 22 carats, all having too light a shade of color.

A discovery of turquoise in California has attracted some attention very lately. At Manvel, near Death Valley, California, Mr. T. C. Bassett observed, on a small hillock, that the "float" rock was full of blue streaks and stains. Upon digging to a depth of 6 feet he struck the true turquoise vein—a white talcose material inclosing nodules and small masses of turquoise. At 20 feet the turquoise showed fine-gem color. From the discovery of two stone hammers there the locality has been named the Stone Hammer mine.

Mr. Henry Durden, curator of the State Mining Bureau, reports that turquoise has been discovered in the desert between Death Valley and Goffs Mining District, nearer the former, in California. Fair examples are in the cabinet of the State Mining Bureau.

ALMANDITE GARNET.

During the last year large quantities of a pale almandite garnet, often almost pink, have been found in the Cowee Valley, in western North Carolina. These have been cut, and extensively sold as American gems.

Mr. Walter Harvey Weed, of the United States Geological Survey, reports the abundant occurrence of almandite garnet at the placers in Post Creek, Montana.

Almandite garnet is reported as plentiful between North and Middle Tule rivers, in Tulare County, California, by Mr. L. B. Hawkins.

Essonite cinnamon garnet at Three Rivers, Tulare County, California, and pyrope at Rattlesnake Creek, Tulare County, California, have been reported by Mr. M. Braverman.

TOURMALINE.

Mr. Dwight Whiting reports that six large, perfect crystals of achroite tourmaline were found at San Jacinto Mountains, Riverside County, California.

Tourmaline cat's-eye.—Among the tourmalines found at Haddam Neck, Connecticut, were a number that had marked internal striations. These striations were quite often minute and abundant, and when the gems were cut across them, generally a good cat's-eye resulted, which showed the line of light quite as well as many Ceylonese chrysoberyl cat's-eyes.

QUARTZ.

Rock crystal.—Mr. W. S. Yeates, State geologist of Georgia, mentions flawless rock crystal from Upson County, Georgia.

Mr. J. A. Udden mentions the occurrence of transparent rock crystal, in the form of rolled pebbles the size of a hen's egg, near Marquette, Kansas.

Rock crystals in masses of several pounds each were found 8 miles east of Visalia, Tulare County, California, by Mr. L. B. Hawkins, and at Yokohl and Three Rivers in the same county, Mr. M. Braverman also found rock crystal.

Mr. John E. Burton, of Wisconsin, reports a discovery of quartz rock crystal of large size in the Green Mountains mine near Mokelumne Hill, Calaveras County, California, found in drifting over 900 feet in the gravel and sand in an old river bed about 700 feet from the channel.

Mr. M. Braverman, of Visalia, reports rose quartz of good quality at Yokohl and Three Rivers, Tulare County, California.

Mr. T. F. Lamb, of Portland, Maine, states that 3 tons of smoky quartz crystals were mined on the Joshua Littlefield farm in Auburn, Maine. This locality is only a few rods from the well-known G. C. Hatch tourmaline locality.

Quartz pebbles.—Plum Island—one of the broken line of morainal islets reaching from the northeastern point of Long Island across the Sound to Watch Hill, Rhode Island—abounds in pebbles of variously colored quartz, derived from the disintegrated rocks of the Connecticut shore and carried southward to the upper or second moraine by the ice sheet. Many of these pebbles are very richly colored—red, yellow, purple, etc.—and have been locally called agates, and collected, both here and on the neighboring Goose Island, by parties from Connecticut. The pebbles are used for the same purposes as stained glass—that is, leaded together—the iron staining showing beautifully by transmitted light. This form of window effect was introduced by Mr. Louis C. Tiffany. The pebbles are very abundant and are continually rolled, washed, and polished by the surf, and sometimes piled on the beach in windrows. One or two persons make a business of visiting the islands in a sloop and gathering the best colored and most attractive stones.

Amethyst.—Mr. J. Terry Dillard, of Livingston, Nelson County, Virginia, reports finding amethyst crystals from 1 to 2 inches in diameter of fair quality for gems.

Mr. W. S. Yeates, State geologist of Georgia, mentions an amethyst, a fine cut gem, in the State Geological Cabinet, from Hall County, Georgia.

Tourmaline in quartz.—Messrs. George N. Tower, jr., and George Otis Smith, of the United States Geological Survey, while on a reconnoissance in southern Utah last season, found some small crystals of quartz, including long needles of tourmaline, at the Cactus mine, Frisco Mountains. The quartz crystals are remarkably beautiful, and they strikingly resemble rutilated quartz and the hornblende in quartz used in Japan to work into quaint art objects.

Hornblende in quartz.—Hornblende in quartz is reported as occurring on Deer Creek, Tulare County, California, by Mr. L. B. Hawkins.

AGATE.

Mr. J. A. Udden, of Rock Island, Illinois, mentions the occurrence of beautiful agate and carnelian pebbles in the terrace gravels along the Mississippi River in that vicinity, although they have not been collected for commercial purposes, but simply by local collectors.

CHALCEDONY.

At Haystack, Crook County, Oregon, Messrs. P. C. Hale and Edmund Healy have found peculiar polished pebbles of white or gray chalcedony, small and translucent, in a hot spring some 40 to 50 feet wide and 10 feet deep, which discharges into a neighboring stream. The pebbles are polished by attrition in the boiling up of the spring, and are found both in the basin and in the ground around to some depth.

Blue (saphirine) chalcedony has been found at Kane Springs, Kern

County, California, in botryoidal masses, of a deep sky-blue color, with rhombohedral crystalline surfaces, quite equal to that found in the Ural Mountains and in Persia.

CHRYSOPRASE.

Mr. M. Braverman records a new locality for chrysoprase (pale green in color) at Deer Creek, Tulare County, California, and one for chalcedony at Drum Valley, in the same county.

The same locality for agate and chrysoprase is also announced by Mr. L. B. Hawkins.

OPAL.

Prof. John E. Wolff, of Harvard University, describes the occurrence of noble (precious) opal, lechosos (milky opal), and hyalite in nodules and lenses in a trachytic tuff associated with beds of basalt at Durkee, Oregon, where active development is being carried on at the present time.

Mr. Henry S. Durden, curator of the California Mining Bureau, reports fire opal, small in size but good in quality, and larger stones, but poor, from Dunsmuir, Siskiyou County, California.

Beautiful yellow opals without fire are reported by Mr. M. Braverman as occurring at the chrysoprase locality at Yokohl, Tulare County, California.

Milky opal has been found by Mr. Dwight Whiting in a narrow seam of sandstone one-half mile east of the NE. ¼, sec. 24, T. 1 S., R. 13 W., San Bernardino B. and M.

One of the most interesting discoveries of opalized wood in the United States was noted by Mr. Warren M. Foote, of Philadelphia, as having been made at Clover Creek, Lincoln County, Idaho. Tons of this material were collected last year, and it is one of the most beautiful of all the opalized woods. The wood itself, in tree form, occurred in a hard volcanic ash that could be removed only by blasting. This discovery is interesting from the remarkable preservation of the cellular tissue and apparent woody structure, so that when the mineral is polished it has the color and luster of a highly polished wood, the color being almost that of quartered oak. The largest sections were 12 inches in diameter.

About 3 tons of silicified wood was found in the Triassic rocks and on the surface at various points in Chesterfield County, Virginia, by Mr. J. B. Woodworth, of the United States Geological Survey.

New South Wales.—The opal mines at White Cliffs, near Wilcannia, New South Wales, described in the last report,[1] have been actively and successfully worked during the last year. Leading European gem dealers now have agents on the ground, thus greatly facilitating purchase. Many claims are in operation, and there are some 400 miners at work. The difficulty of obtaining accurate data as to sales, etc., before referred to, still exists. The best estimates assign to the output for 1896 a value of $125,000, surpassing that of the previous year several fold.

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[1] Mineral Resources of the United States, 1896; Precious Stones, by George F. Kunz: Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (continued), 1897, pp. 1208-1209.

Queensland.—The Queensland opal industry[1] does not seem to be very systematically carried on, most of the work being done in an irregular way by men who follow it in the intervals of other occupation. The localities are in the western and southwestern parts of the colony, and, like those of New South Wales,[2] are in Cretaceous rocks, with the opal occurring in irregular patches, forming layers or "bands" down to the depth of 40 feet.

Turkey.—Announcement has been made by one of the technical journals of the discovery of an opal mine at Ak-dagh, near Kavandji, in the district of Kutahuja and vilayet of Hudavendighiar, Turkey. The ministry of mining and agriculture has granted a concession to parties, whose nationality is not reported, to operate this mine for ninety-nine years.

CYANITE.

Mr. J. H. Pratt has described[3] a very interesting form of crystallized cyanite found on the farm of Mr. Tiel Young, near North Toe River, Yancey County, North Carolina, a few miles from Spruce Pine, Mitchell County. Many of the crystals are of rich mossy green color, transparent in part. Occasionally, however, the crystals have grass-green margins with deep blue centers. As many of the crystals are terminated, this is probably the best locality of this interesting mineralogical gem discovered in recent years.

RHODONITE.

Rhodonite in small pieces, of fair color, is in the Georgia State geological cabinet, as coming from Dekalb County, brought by Mr. W. S. Yeates, State geologist.

GEM COLLECTIONS AND LITERATURE.

At the Tennessee Centennial Exposition, at Nashville, much attention was attracted by the fine collection of minerals, especially gems and gemstones, belonging to Gen. George P. Thruston, of Nashville. It was displayed in the Historical Building, and was described as a collection of "the minerals of jewelry." A great variety of choice crystals and cut stones from all parts of the world was here represented, though the gems from America, and especially southern localities, attracted particular notice because of their local interest. The finest cut amethyst was from North Carolina. A series of amethyst specimens, ranging from the faintest tint to the deepest purple, was shown. North Carolina emeralds were also represented, and much besides.

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[1] See Mineral Resources of the United States, 1895: Seventeenth Ann. Rept. U. S. Geol. Survey, Part III (continued), 1896, p. 915.

[2] Mineral Resources of the United States, 1896; Precious Stones, by George F. Kunz: Eighteenth Ann. Rept., U. S. Geol. Survey, Part V (continued), 1897, pp. 1208-1209.

[3] Am. Jour. Sci. for February, 1898, 4th series, Vol. V, pp. 126-127.

Mr. E. R. Chadwick, of Lewiston, Maine, placed a fine collection of gem and other minerals in the granite building erected by the State of Maine at the Chicago World's Fair. The collection has been transferred to Poland, Maine, where it has been opened as a museum with a library added to it.

Bibliography of X-Ray Literature and Research, 1896–97, by Charles E. S. Phillips, New York, 1897, is a ready-reference index to the literature on the subject of Röntgen rays, or x-rays. It is a carefully prepared bibliography of great value to those interested in studying the properties of gems and other substances by this new agency. The volume includes references to all important papers that have appeared up to March, 1897, a brief summary or retrospect of the historical development of the subject, and a chapter ("Practical hints") by the editor, giving suggestions as to the best methods of overcoming some of the mechanical difficulties involved.

The year 1897 witnessed the decease of two persons whose names are closely connected with both the discovery and the development of the mineral wealth of North Carolina, Mr. J. Adlai D. Stevenson, of Statesville, who died in May, at the age of 74, and ex-Senator Thomas L. Clingman, who died in October, aged 85.

Mr. Stevenson was a self-made man, of great practical judgment and ability, and of high integrity and generous disposition. He was all his life a North Carolinian, rarely leaving his own State, but knowing its people and its resources as did few others. Most of his life and activity was spent in Alexander and Iredell counties. The fields, the forests, the mountains, and the mineral resources of that region were all familiar to him, and he was universally looked up to as an authority in all local matters.

Among the many results of Mr. Stevenson's keen and active interest in mineralogy, probably the most important was the discovery of the celebrated locality at Stony Point, Alexander County, where were found the emerald crystals and subsequently the "lithia emeralds," hiddenite, or transparent green spodumene, that for a time attracted so much attention. Mr. Stevenson had engaged the farmers and country people, especially children, to look for and preserve the beryl crystals and other peculiar minerals that were at times seen in the soil formed of the rock decomposed in place. He had told them that dark-green beryls would be of important value, and had given them much stimulating information. He soon began to receive specimens of these "green bolts," as the people called them, and in the years 1875 to 1880 he gathered a fine collection. In 1879 hiddenite crystals were found in the soil, and were sent by him to the late Mr. Norman Spang, of Pittsburg, under the impression that they were remarkably fine diopsides. Later he showed them to Mr. W. E. Hidden, who sent specimens to Prof. J. Lawrence Smith, of Louisville, by whom they were identified as spodumene, and named after Mr. Hidden. The Stevenson collection of quartz, beryls and other North Carolina minerals has been purchased by the State of North Carolina and placed in the State collection at Raleigh.

The late Gen. T. L. Clingman was a graduate of the University of North Carolina, and became a lawyer at Asheville. After serving in the legislature for a time, he was sent to Congress for repeated terms; first to the House and then to the Senate, whence he withdrew in 1861, to follow his State. He became first a colonel, and then a brigadier-general, in the Southern army, and served to the end of the war. Subsequently he devoted his attention to literary and scientific pursuits, in which he had always been interested. Years before, in 1855, he had measured the altitude of the highest point of the Black Mountains, since named Clingmans Peak; this he published through the Smithsonian Institution; and in 1858 he determined the height of the loftiest point of Smoky Mountain, now known as Clingmans Dome.

General Clingman was greatly interested in developing the mineral wealth of his State, and first opened the mica mines in Mitchell and Yancey counties. As far back as 1845 he became the possessor of a diamond from the gold washings of Twitty's mine in Rutherford county—the third stone obtained in the State, but the first to attract much attention. This diamond, a distorted octahedron, over 4 grains in weight, clear but slightly yellowish, was described by Prof. C. U. Shepard.[1] A few years later he sent Professor Shepard several pounds of coarse blue sapphire, broken from a large crystal picked up at the base of a mountain, on the French Broad River, in Madison County. This was among the earliest notices of the occurrence of corundum in North Carolina, which has since become so important. General Clingman also worked the zircon deposits a decade before the new incandescent gas lights were introduced; and he conducted various other investigations relating to rare and valuable minerals. and greatly aided in making known the resources of the State.

RONDELLE AND OVOID GEMS.

During the year 1897 the rondelle form of gem was cut more extensively and in greater variety than ever before. The rondelle, or flat circular bead with faceted edge, from 5 to 20 mm. in diameter, is made not only of diamond, but also of ruby, sapphire, emerald, amethyst, topaz, yellow beryl, and white topaz, as well as transparent quartz. These were strung among various gems, as were the diamonds between pearls. They were also placed in the center of some ovoid gems—that is, gems cut in an ovoid or egg shape—both ends being alike and brought together in the center and the rondelle gem placed between. In all white gems—either diamond, white topaz, or white crystal—or placed between opal or amethyst, or even jade, the effect is to light up the gem in a remarkably pleasing manner, adding much to its beauty. In this form it was much used for necklaces or bracelets, especially in the new long form of necklace, frequently from 50 to 60 inches in length, called by the French *sautoir*. These rondelles were also used between topaz, agate, onyx, chrysoprase, and the endless series of natural and artificially colored chalcedony, tiger-eye, etc.

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[1] See Am. Jour. Sci., for September, 1846, 2d series, Vol. II, pp. 253-254.

HARDNESS OF MINERALS AND PRECIOUS STONES.

An important article, by Mr. T. A. Jaggar, jr., of Cambridge, Massachusetts, upon the hardness of minerals and precious stones, and the methods of testing and determining it, has recently appeared.[1]

The article, which is entitled A Microsclerometer for determining the Hardness of Minerals, embodies the results of a research carried on in the petrographical laboratory of Harvard University, and contains much valuable matter in addition to the detailed description of a new and exceedingly delicate and complicated instrument.

Mr. Jaggar begins with a summary of the various methods employed or suggested by different writers—mineralogists, metallurgists, and physicists—for determination of hardness. These are grouped under the four heads of (1) abrasion, (2) penetration, (3) friction, and (4) fracture. A discussion then follows as to the conditions requisite to really accurate hardness tests. Here some very careful discriminations are made as to the relation of results to the hardness of the abrader, to the interaction between it and the substance tested, to the atomic, molecular, and mechanical structure of the latter, jointly or severally, and the like, many of which are of much physical interest. Then, after stating the objects sought to be attained in its construction and the principles accepted as its basis, the instrument is described at length.

The penetration method is selected as best capable of accurate measurement. The abrader chosen is diamond, a perfectly regular cleavage tetrahedron, easily obtained among diamond chips, being employed, and microscopically examined for an exactly equal solid angle, which is then fixed with perfect accuracy of centering on the point of a small rotating "mount." This last projects vertically downward from the end of a delicate horizontal beam provided with all manner of refined devices for adjusting, weighting, locking and releasing, etc.; and the rotary motion is given from a wheel at the other end, operated by hand, or, in Mr. Jaggar's later studies, by clockwork. The whole apparatus is arranged to be clamped to the base of a Fuess No. 1 microscope in such wise that the placing and orienting of the crystal or other section to be tested, the adjustment of the point to its surface, and the progress of the operation can all be either observed under high powers, measured by delicate micrometers, or accurately and automatically recorded. The known rate of rotation with a given weight, the number of revolutions being read off from a register, then gives the amount of resistance in boring to a depth of 10 microns (0.01 mm.)—the usual limit—as carefully watched during the process on the micrometer focused under the objective. It is impossible without illustrations to describe the complicated adjustments of this remarkable instrument.

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[1] Am. Jour. Sci. for Dec., 1897, 4th series, Vol. IV, pp. 399-412; also Zeitschr. für Krystallographie, etc., Leipsic, Vol. XXIX, Part III, 1898, pp. 262-275.

Some of the results obtained by Mr. Jaggar are given at the close of the paper. In these there is brought out very strikingly the fact, already known, but not very familiar, that the differences in hardness between the minerals of the ordinary Mohs scale increase enormously in passing from the lower to the higher numbers. With a uniform weight of 10 gm., and all other conditions alike, the hardness, as given in revolutions of the diamond point necessary to bore to a depth of 10 microns, appears as follows (from 2 to 9 Mohs): Gypsum, 8.3; calcite (cleavage), 50; fluorspar (octahedral cleavage), 143; apatite (basal), 233; orthoclase (cleavage P), 4,665; quartz (basal), 7,648; topaz (basal), 28,867; corundum (rhombohedral), 188,808. Reduced to the standard (corundum, 1,000) adopted by Rosiwal, and arranged for comparison with the results published by Plaff in 1884 and Rosiwal in 1892, this increase of the hardness ratio becomes far more marked in these latest tests, as shown by the following table:

Relative hardness of gems.

	Plaff.	Rosiwal.	Jaggar.
Corundum	1,000	1,000	1,000
Topaz	459	138	152
Quartz	254	149	40
Orthoclase	191	28.7	25
Apatite	53.5	6.20	1.23
Fluorite	37.3	4.70	.75
Calcite	15.3	2.68	.26
Gypsum	12.03	.34	.04

The instrument is also capable of other applications in physical mineralogy, which can not be dwelt upon here.

PRODUCTION.

In the following table is given a statement of the production of precious stones in the United States in 1896 and 1897:

Production of precious stones in the United States in 1896 and 1897.

	1896.	1897.
Diamond	None.	None.
Sapphire	$10,000	$25,000
Ruby	1,000	None.
Topaz	200	None.
Beryl (aquamarine, etc.)	700	1,500
Emerald	None.	25
Phenacite	None.	None.
Tourmaline	3,000	9,125
Peridot	500	500
Quartz, crystal	7,000	12,000
Smoky quartz	2,500	1,000
Rose quartz	500	None.
Amethyst	500	200
Prase	100	None.
Gold quartz	10,000	5,000
Rutilated quartz	500	None.
Dumortierite in quartz	50	None.
Agate	1,000	1,000
Moss agate	1,000	1,000
Chrysoprase	600	None.
Silicified wood (silicified and opalized)	4,000	2,000
Opal	200	200
Garnet (almandite)	500	7,000
Garnet (pyrope)	2,000	2,000
Topazolite	100	None.
Amazon stone	1,000	500
Oligoclase	500	25
Moonstone	250	None.
Turquoise	40,000	55,000
Utahlite (compact variscite)	500	100
Chlorastrolite	500	500
Thomsonite	500	500
Prehnite	100	100
Diopside	200	100
Epidote	250	None.
Pyrite	1,000	1,000
Rutile	100	800
Anthracite	2,000	1,000
Catlinite (pipestone)	3,000	2,000
Fossil coral	1,000	500
Arrow points	1,000	1,000
Total	97,850	130,675

IMPORTS.

The following table shows the diamonds and other precious stones imported into the United States from 1867 to 1897:

Diamonds and other precious stones imported and entered for consumption in the United States, 1867 to 1897, inclusive.

Years ending—	Diamonds.					Diamonds and other stones not set.	Set in gold or other metal.	Total.
	Glaziers'.	Dust.	Rough or uncut.	Set.	Unset.			
June 30, 1867....	$906	....	....	......	....	$1,317,420	$291	$1,318,617
1868....	484	....	....	......	....	1,060,544	1,465	1,062,493
1869....	445	$140	....	......	....	1,997,282	23	1,997,890
1870....	9,372	71	....	......	....	1,768,324	1,504	1,779,271
1871....	976	17	....	......	....	2,349,482	256	2,350,731
1872....	2,386	89,707	....	......	....	2,939,155	2,400	3,033,648
1873....	....	40,424	$176,426	......	....	2,917,216	326	3,134,392
1874....	....	68,621	144,629	......	....	2,158,172	114	2,371,536
1875....	....	32,518	211,920	......	....	3,234,319	....	3,478,757
1876....	....	20,678	186,404	......	....	2,409,516	45	2,616,643
1877....	....	45,264	78,033	......	....	2,110,215	1,734	2,235,246
1878....	....	36,409	63,270	......	....	2,970,469	1,025	3,071,173
1879....	....	18,889	104,158	......	....	3,841,335	538	3,964,920
1880....	....	49,360	129,207	......	....	6,690,912	765	6,870,244
1881....	....	51,409	233,596	......	....	8,320,315	1,307	8,606,627
1882....	....	92,853	449,513	......	....	8,377,200	3,205	8,922,771
1883....	....	82,628	443,996	......	....	7,598,176	[f] 2,081	8,126,881
1884....	22,208	37,121	367,816	......	....	8,712,315	....	9,139,460
1885....	11,526	30,426	371,679	......	....	5,628,916	....	6,042,547
Dec. 31, 1886....	8,949	32,316	302,822	......	....	7,915,660	....	8,259,747
1887....	9,027	33,498	262,357	......	....	10,526,998	....	10,831,880
1888....	10,025	29,127	244,876	......	....	10,223,630	....	10,507,658
1889....	8,156	68,746	196,294	......	....	11,704,808	....	11,978,004
1890....	147,227	179,154	349,915	......	....	[d] 12,429,395	....	13,105,691
1891....	[a] 565,623	125,688	(c)	......	....	[e] 12,065,277	....	12,756,588
1892....	532,246	144,487	....	......	....	[e] 13,845,118	....	14,521,851
1893....	357,939	74,255	....	......	....	[e] 9,765,311	....	10,197,505
1894....	82,081	53,691	....	......	....	[e] 7,291,342	....	7,427,214
1895....	107,463	135,558	....	......	....	[e] 6,330,834	....	6,573,855
1896....	78,990	65,690	....	......	....	[e] 4,474,311	....	4,618,991
1897....	[b] 29,576	167,118	1,386,726	$330	$2,789,924	1,903,055	....	6,276,729

[a] Including also engravers', not set, and jewels to be used in the manufacture of watches, from 1891 to 1894; from 1894 to 1896 miners' diamonds are also included.

[b] Including also miners' and engravers', not set.

[c] Included with diamonds and other stones from 1891 to 1896.

[d] Includes stones set and not specially provided for since 1890.

[e] Including rough or uncut diamonds.

[f] Not specified since 1883.

ABRASIVE MATERIALS.

By Edward W. Parker.

BUHRSTONES.

PRODUCTION.

Buhrstones or millstones of domestic production are made from a quartz-conglomerate rock occurring in several localities along the eastern slope of the Allegheny Mountains. The production at the present time is limited to three places: One is in New York, in the vicinity of the towns of Accord, Kerhonkson, and Kyserike, in Ulster County; the second is in Lancaster County, Pennsylvania; and the third is in Montgomery County, Virginia. Local designations are applied to the stone in these several districts. The New York product is given the name "Esopus stone;" the Pennsylvania product is termed "Cocalico stone;" while the Virginia stone is known as "Brush Mountain stone." Though this conglomerate rock is used in the manufacture of millstones, and is classed as buhrstone, it is entirely distinct from the imported French, Belgian, and German buhr. Of the imported buhrs the French and Belgian are hard, porous stone composed of small particles of silica cemented by calcareous material, while the German is said to be of basaltic lava.

The buhrstones of commerce made from imported material are composed of comparatively small pieces fitted to one another and bound into solid wheels. The domestic millstones are cut out of the solid rock in one piece. They are used in pairs for the grinding of paint ore, cement rock, phosphate rock, bone, and the coarser cereals. Their use in flouring mills, except in isolated cases, has been supplanted by the modern roller process. The result of the introduction of the roller process in flouring mills is exhibited in the statistics of the production of millstones from domestic rock and the value of buhr and buhrstones imported into this country. In 1880 the value of the millstones made in the United States was placed at $200,000, while imported buhr and buhrstones were valued at $125,072. In 1889 the value of the product of domestic millstones had fallen to $35,155, and the value of the imports to $40,884, the total being less than one-fourth of what it was in 1880. In 1894 the domestic product had fallen to a value of only $13,887, while the imports were worth only $18,087, the aggregate being about 42 per cent of what it was in 1889 and only 10 per cent of what it was in 1880. Since 1894 there has been a slight increase in production. The value of the millstones made in the United States during 1897 was $25,932, an increase over 1896 of $3,365. The value of the imports in 1897 was $22,956, a decrease as compared with the preceding year of $4,009. Compared with the production in 1880, that for the last nine years seems hardly worth recording, for, while the value in 1897 was less than $26,000, it is the largest figure reported since 1889.

In the following table is exhibited the value of the millstones produced in the United States since 1880:

Value of buhrstones produced in the United States from 1880 to 1897.

Year.	Value.	Year.	Value.
1880	$200,000	1889	$35,155
1881	150,000	1890	23,720
1882	200,000	1891	16,587
1883	150,000	1892	23,417
1884	150,000	1893	16,639
1885	100,000	1894	13,887
1886	140,000	1895	22,542
1887	100,000	1896	22,567
1888	81,000	1897	25,932

IMPORTS.

The following table gives the value of buhrstones and millstones imported into the United States each year since 1868:

Value of buhrstones and millstones imported into the United States from 1868 to 1897.

Year ended—	Rough.	Made into millstones.	Total.
June 30, 1868	$74,224	....	$74,224
1869	57,942	$2,419	60,361
1870	58,601	2,297	60,898
1871	35,406	3,698	39,104
1872	69,062	5,967	75,029
1873	60,463	8,115	68,578
1874	36,540	43,170	79,710
1875	48,068	66,991	115,059
1876	37,759	46,328	84,087

Value of buhrstones and millstones imported into the United States from 1868 to 1897—Continued.

Year ended—	Rough.	Made into millstones.	Total.
June 30, 1877	$60,857	$23,068	$83,925
1878	87,679	1,928	89,607
1879	101,484	5,088	106,572
1880	120,441	4,631	125,072
1881	100,417	3,495	103,912
1882	103,287	747	104,034
1883	73,413	272	73,685
1884	45,837	263	46,100
1885	35,022	455	35,477
Dec. 31, 1886	29,273	662	29,935
1887	23,816	191	24,007
1888	36,523	705	37,228
1889	40,432	452	40,884
1890	32,892	1,103	33,995
1891	23,997	42	24,039
1892	33,657	529	34,186
1893	29,532	729	30,261
1894			*a* 18,087
1895			20,316
1896			26,965
1897			22,956

a Not separately classified after 1893.

GRINDSTONES.

OCCURRENCE.

Grindstones of domestic manufacture are obtained from the sandstone deposits which extend along the shores of Lake Erie for some distance east and west of Cleveland, Ohio, and as far inland as Marietta, and on Lake Huron above Detroit, Michigan. In Mineral Resources for 1886 the methods of manufacture and use are given in detail, together with a tabular statement of the several varieties, foreign or domestic, that occur, with their special uses. Five varieties are produced in the United States—four in Ohio and one in Michigan. The four in Ohio are: (1) Berea, fine sharp grit, used specially for sharpening edge tools; (2) Amherst, soft loose grit, for edge tools and saws; (3) Independence, coarse sharp grit, for grinding springs and files and for dry grinding of castings; (4) Massillon, also coarse sharp grit, for large edge tools, springs, files, and dry castings. The Huron (Michigan) stone has a fine sharp grit, and is used for sharpening edge tools when a very fine edge is required.

PRODUCTION.

In the report for 1896 comment was made on the wholesome recovery in the grindstone industry from the depression which marked the trade conditions in 1894 and 1895, the value of the product in 1896 being a little more than 75 per cent of the value of the output in the two previous years combined. The returns for 1897 show that the improved conditions continued, the value of the grindstones made in the year just past exceeding that of any year since 1891. The value of the product during 1897 was $368,058, against $326,826 in 1896 and $205,768 in 1895.

In reporting their production some manufacturers use the ton as a unit of quantity; others report the number of grindstones made and sold, while still others state simply the total value of their output. Under such conditions the only means for obtaining a total statement and for making comparisons is in using the value of the product. In reporting the imports of grindstones the Bureau of Statistics of the Treasury Department also limits the statements to the value, no figures relating to quantities having been published since 1883. The value of the grindstones imported during the decade ending December 31, 1897, has averaged 15.3 per cent of the domestic product. During this period the greatest value for the domestic product was in 1891, when a total of $476,113 was reported. The value of the imports reached the highest figure ($66,195) in 1896. The smallest domestic product was in 1895, the value in that year amounting to only $205,768, and the year of least value of the imports was in 1891, when it amounted to $21,028.

In the following table is shown the value of grindstones produced in the United States since 1880:

Value of grindstones produced in the United States, 1880 to 1897.

Year.	Value.	Year.	Value.
1880	$500, 000	1889	$439, 587
1881	500, 000	1890	450, 000
1882	700, 000	1891	476, 113
1883	600, 000	1892	272, 244
1884	570, 000	1893	338, 787
1885	500, 000	1894	223, 214
1886	250, 000	1895	205, 768
1887	224, 400	1896	326, 826
1888	281, 800	1897	368, 058

IMPORTS.

The amount and value of grindstones imported into the United States since 1868 are as follows:

Grindstones imported and entered for consumption in the United States, 1868 to 1897, inclusive.

Year ended—	Finished.		Unfinished or rough.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		
June 30, 1868		$25,640		$35,215	$60,855
1869		15,878		99,715	115,593
1870		29,161		96,444	125,605
1871	385	43,781	3,957.15	60,935	104,716
1872	1,202	13,453	10,774.80	100,494	113,947
1873	1,437	17,033	8,376.84	94,900	111,933
1874	1,443	18,485	7,721.44	87,525	106,010
1875	1,373	17,642	7,656.17	90,172	107,814
1876	1,681	20,262	6,079.34	69,927	90,189
1877	1,245	18,546	4,979.75	58,575	77,121
1878	1,463	21,688	3,669.41	46,441	68,129
1879	1,603	24,904	4,584.16	52,343	77,247
1880	1,573	24,375	4,578.59	51,899	76,274
1881	2,064	30,288	5,044.71	56,840	87,128
1882	1,705	30,286	5,945.61	66,939	97,225
1883	1,755	28,055	6,945.63	77,797	105,852
1884					[a]86,286
1885					50,579
Dec. 31, 1886					39,149
1887					50,312
1888					51,755
1889					57,720
1890					45,115
1891					21,028
1892					61,052
1893					59,569
1894					52,688
1895					54,276
1896					66,195
1897					49,496

[a] Since 1884 classed as finished or unfinished.

CANADIAN PRODUCTION.

The Geological Survey of Canada gives the following statement of the production of grindstones in the Dominion since 1886:

Production of grindstones in Canada since 1886.

Calendar year.	Tons.	Value.
1886	4,000	$46,545
1887	5,292	64,008
1888	5,764	51,129
1889	3,404	30,863
1890	4,884	42,340
1891	4,479	42,587
1892	5,283	51,187
1893	4,600	38,379
1894	3,757	32,717
1895	3,475	31,932
1896	3,663	32,810
1897	....	40,000

OILSTONES AND WHETSTONES.

PRODUCTION.

The production of this class of abrasives in 1897 consisted of 846,000 pounds of oilstones and water whetstones, 200,000 pounds of shoemaker's rubstones, 40,000 pounds of kitchen rubstones, 150,000 pounds of coarser sandstones, and 18,000 gross of scythestones. These represented in value a total of $149,970, against $127,098 in 1896. While this shows an increase in 1897 of about 18 per cent over 1896, it was nearly $6,000 less than the value of the product in 1895.

The rough material from which our oilstones, etc., are made is obtained from various localities in the United States. The finer grades of oilstones are made from two grades of novaculite quarried in the vicinity of Hot Springs, Arkansas, and known, respectively, as "Arkansas" and "Washita" stone. Fine-grained sandstone, called "Hindostan" or "Orange" stone, from Orange County, Indiana; Lake Superior stone, quarried in Cuyahoga County, Ohio, and a similar material, known as Labrador stone, from Cortland County, New York, and chocolate stone, from Lisbon, New Hampshire, are used for whetstones. Scythestones and rubstones are made from Indian Pond and Lamoille stone, quarried in Grafton County, New Hampshire, and Orleans County, Vermont; from Berea, Ohio, grit (which also furnishes grindstones), and from some of the Indiana sandstone.

The principal manufacturer of oilstones, whetstones, etc., in the United States is the Pike Manufacturing Company, of Pike Station, New Hampshire, the output of this company in 1897 being valued at nearly $141,000, out of a total of $149,970. This company owns quarries at French Lick, Georgia, Orangeville and Paoli, Indiana; Haverhill, Piermont, Orford, and Lisbon, New Hampshire; Truxton, New York, and Westmore and Browninglon, Vermont; and besides having its own quarries and 1,000 acres of quarry land in Garland County, Arkansas, the company has contracted with all the individual quarrymen for their entire output for a number of years. During 1896 the Pike Company erected a mill at Hot Springs, Arkansas, for cutting and finishing the novaculite quarried in that vicinity, and discontinued the manufacture of Labrador stone from Cortland County, New York.

Under existing circumstances the first uniform selling value that can be placed upon the product is for the finished articles, which for the last six years has been as follows:

Value of oilstones, whetstones, etc., produced in the United States since 1891.

Year.	Value.
1891	$150,000
1892	146,730
1893	135,173
1894	136,873
1895	155,881
1896	127,098
1897	149,970

From 1880 to 1890, inclusive, the product and value of the rough stone has been published in these reports, exception being made in the case of the output for 1890, when the value for the unfinished product was given for the novaculite of Arkansas, and in all other cases the value of the finished stones is quoted. The annual production from 1880 to 1890 was as follows:

Product of oilstones and whetstones from 1880 to 1890.

Year.	Pounds.	Value.
1880	420,000	$8,000
1881	500,000	8,580
1882	600,000	10,000
1883	600,000	10,000
1884	800,000	12,000
1885	1,000,000	15,000
1886	1,160,000	15,000
1887	1,200,000	16,000
1888	1,500,000	18,000
1889	5,982,000	32,980
1890		69,909

The reports of production by the Pike Manufacturing Company have been furnished this office annually since 1892, with permission to publish. They may be taken as indicative of the condition of the industry, and are shown in the following table. These figures are not claimed to be exact, but are estimated, though sufficiently approximate for all practical purposes.

Production of oilstones, etc., by the Pike Manufacturing Company since 1892.

Kind.	1892.		1893.		1894.	
	Output.	Value.	Output.	Value.	Output.	Value.
Washita stone.pounds..	400,000	$60,000	300,000	$45,000	300,000	$45,000
Arkansas stone...do....	20,000	12,000	12,000	12,000	15,000	15,000
Labrador stone...do....	500	50	200	20	100	10
Hindostan stone..do....	300,000	15,000	250,000	13,000	300,000	15,000
Sandstone ....do....	100,000	2,000	100,000	2,000	100,000	2,200
Chocolate stone..do....	20,000	2,000	20,000	2,000	25,000	2,500
Scythestones ....gross..	16,000	50,000	13,000	40,000	15,000	45,000
Total value.......	....	141,050	....	114,020	....	124,710

Kind.	1895.		1896.		1897.	
	Output.	Value.	Output.	Value.	Output.	Value.
Washita stone.pounds..	250,000	$40,000	240,000	$50,000	500,000	$75,000
Arkansas stone...do....	15,000	20,000				
Hindostan stone..do....	300,000	12,000	275,000	10,000	320,000	12,800
Sandstone ....do....	100,000	2,000	100,000	2,000	150,000	3,000
Chocolate stone..do....	10,000	1,000	10,000	1,000	5,000	100
Scythestones ....gross..	15,000	47,750	15,000	35,000	16,000	50,000
Total value.......	....	122,750	....	98,000	....	140,900

IMPORTS.

The following table shows the total value of all kinds of hones and whetstones imported since 1880:

Imports of hones and whetstones since 1880.

Year ended—	Value.	Year ended—	Value.
June 30, 1880	$14,185	Dec. 31, 1889	$27,400
1881	16,631	1890	37,454
1882	27,882	1891	35,344
1883	30,178	1892	33,420
1884	26,513	1893	25,301
1885	21,434	1894	26,671
Dec. 31, 1886	21,141	1895	32,439
1887	24,093	1896	50,588
1888	30,676	1897	34,485

CORUNDUM AND EMERY.

PRODUCTION.

During the last three years the total amount of corundum and emery mined and marketed has been without material change. The product in 1897 aggregated 2,165 short tons, against 2,120 tons in 1896 and 2,102 tons in 1895. The principal feature of the industry in 1897 was the increase in the shipments of emery from Westchester County, New York. In 1896 the shipments from this region amounted to 633 short tons; in 1897 the shipments were 949 tons, indicating an increase of exactly 50 per cent. During 1895 the shipments were about the same as in 1897. The production in Massachusetts increased about 10 per cent over 1896. North Carolina corundum shipments were less in 1897 than in the preceding year, but indications point to a considerable increase in the business for 1898. A recent discovery is reported of the occurrence of corundum deposits differing from those which have so far been worked. This new discovery is said to consist of a lode formation traceable for 3 miles, having a width of from 8 to 12 feet and containing three "pay streaks" from 2 to 4 feet each in width.[1] This lode is said to yield ore giving 45 per cent clean corundum crystals, ranging in size from one-twentieth of an inch to the size of a hickory nut.

The corundum and emery mining industry has suffered considerably during the last few years from the general depression in values. This has resulted in the closing down of a number of small operations in North Carolina, leaving at the present time only two companies in that field. One of these, the Hampden Emery and Corundum Company, also controls the Massachusetts mines and formerly operated a mine in Georgia. The Georgia mine has been abandoned for several years, the company now confining its business to Massachusetts and North Carolina. The National Abrasive Manufacturing Company, formerly the Savannah Mining Company of Dillsboro, was the only other company producing corundum in North Carolina during 1897. Two new organizations said to possess ample capital expect to enter the field in 1898. These are the Turkey Knob Corundum Company of Baltimore, Maryland, and the Isbell Corundum Company of Asheville, North Carolina.

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[1] Leverett S. Ropes, in Manufacturer's Record, January 28, 1898.

The producers of both emery and corundum are averse to giving publicity to their business, and in order to maintain the confidential nature of the statistics the production of the two minerals is stated together in the following table:

Annual product of corundum and emery since 1881.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1881	500	$80,000	1890	1,970	$89,395
1882	500	80,000	1891	2,247	90,230
1883	550	100,000	1892	1,771	181,300
1884	600	108,000	1893	1,713	142,325
1885	600	108,000	1894	1,495	95,936
1886	645	116,190	1895	2,102	106,256
1887	600	108,000	1896	2,120	113,246
1888	589	91,620	1897	2,165	106,574
1889	2,245	105,567			

IMPORTS.

The corundum used in the United States is exclusively of domestic production. Emery is imported from Turkey and the island of Naxos, one of the Cyclades group in the Grecian Archipelago.

The following table shows the imports of emery from 1867 to 1897:

Emery imported into the United States from 1867 to 1897, inclusive.

Year ended—	Grains.		Ore or rock.		Pulverized or ground.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	
June 30—	*Pounds.*		*Long tons.*		*Pounds.*			
1867	....	....	428	$14,373	924,431	$38,131	....	$52,504
1868	....	....	85	4,531	834,286	33,549	....	38,080
1869	....	....	964	35,205	924,161	42,711	....	77,916
1870	....	....	742	25,335	644,080	29,531	....	54,866

Emery imported into the United States from 1867 to 1897, inclusive—Continued.

Year ended—	Grains.		Ore or rock.		Pulverized or ground.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	
June 30—	*Pounds.*		*Long tons.*		*Pounds.*			
1871..	....	....	615	$15,870	613,624	$28,941	....	$44,811
1872..	....	....	1,641	41,321	804,977	36,103	....	77,424
1873..	610,117	$29,706	755	26,065	343,828	15,041	$107	70,919
1874...	331,580	16,216	1,281	43,886	69,890	2,167	97	62,366
1875..	487,725	23,345	961	31,972	85,853	2,990	20	58,327
1876..	385,246	18,999	1,395	40,027	77,382	2,533	94	61,653
1877..	343,697	16,615	852	21,964	96,351	3,603	....	42,182
1878..	334,291	16,359	1,475	38,454	65,068	1,754	34	56,601
1879..	496,633	24,456	2,478	58,065	133,556	4,985	....	87,506
1880..	411,340	20,066	3,400	76,481	223,855	9,202	145	105,894
1881..	454,790	22,101	2,884	67,781	177,174	7,497	53	97,432
1882..	520,214	25,314	2,765	69,432	117,008	3,708	241	98,695
1883..	474,105	22,767	2,447	59,282	93,010	3,172	269	85,490
1884..	143,267	5,802	4,145	121,719	513,161	21,181	188	148,890
1885..	228,329	9,886	2,445	55,368	194,314	8,789	757	74,800
Dec. 31—								
1886..	161,297	6,910	3,782	88,925	365,947	24,952	851	121,638
1887..	367,239	14,290	2,078	45,033	[a]144,380	6,796	2,090	68,209
1888..	430,397	16,216	5,175	93,287	....	....	8,743	118,246
1889..	503,347	18,937	5,234	88,727	....	....	111,302	218,966
1890..	534,968	20,382	3,867	97,939	....	....	5,046	123,367
1891..	90,658	3,729	2,530	67,573	....	....	....	71,302
1892..	566,448	22,586	5,280	95,625	....	....	2,412	120,623
1893..	516,953	20,073	5,066	103,875	....	....	3,819	127,767
1894..	597,713	18,645	2,804	51,487	....	....	1,841	71,973
1895..	678,761	25,066	6,803	80,386	....	....	27,586	133,038
1896..	755,693	28,493	6,389	119,738	....	....	....	148,231
1897..	539,176	20,665	5,213	107,655	....	....	2,211	130,531

[a] To June 30, only; since classed with grains.

CORUNDUM IN ONTARIO, CANADA.

Prof. Courtenay DeKalb, of the Kingston School of Mining, Kingston, Ontario, has been making some interesting tests upon corundum rock from a deposit in Hastings County, discovered about a year ago by a member of the geological survey. The tests were to ascertain the composition of the rock, and the best mode of concentrating the corundum from it and also to find if grades of sufficient purity to serve as an ore of aluminum could be economically produced. As an ore of aluminum the crude corundum is said to be richer than bauxite and cryolite, from which the metal aluminum is now obtained. The experiments are not yet completed, and the full results will not be made known until the next report of the bureau of mines is issued. A preliminary announcement covering a part of the investigations has, however, appeared. According to this, Professor De Kalb has found that the quantity of corundum is greater in the coarser than in the medium or finer sizes. This knowledge is valuable as an aid to the separation of the purer grades of corundum in concentration. The ore examined was found to contain 15.5 per cent of corundum and 4½ per cent of magnetite. Further tests show that concentrates may be produced giving 85 to 99 per cent of corundum, and as the commercial standard of purity requires only 80 per cent, it appears that this limit can be easily passed in treating these rocks. The most important object of the tests was to find the best means of separating the corundum from its gangue. Of this the preliminary report does not say much, as the experiments were incomplete, but enough has been done to show that the rock can be treated economically. As to whether it can be turned to account profitably or practically as a base of aluminum Professor De Kalb is not yet prepared to say. But for the material of abrasive wheels corundum is pronounced by the bureau of mines to be superior to emery.

After the discovery of the Hastings deposit, a considerable tract in the vicinity, being in the public domain, was withdrawn from sale by the Ontario crown lands department. W. G. Miller, professor of geology in the Kingston School of Mining, was employed to examine the district, and determine the areas in which the mineral was to be found. He spent ten weeks in the northern part of Hastings and the southern part of Renfrew, and defined a corundum belt, in which outcrops of the mineral occur at intervals, 30 miles long and on the average 3 miles broad, the extreme points being Carlow in the west and Sebastopol in the east. Mr. Miller found the corundum to occur in dikes and masses of syenite and, sometimes, nepheline-syenite which cut a dark gneiss. The gneiss has the acidity of a gabbro or diorite. All these rocks are of Laurentian age. There are indications of another belt farther north. It is also suspected that a third, possibly parallel, belt exists to the south of the one examined, as corundum has been found occurring under the same conditions in the township of Methuen, Peterborough County, situated about 40 miles to the southwest of Carlow. The district is easy of access, has good shipping facilities, and is well supplied with water power. A report on the corundum district, accompanied by maps, is being published by the Ontario Bureau of Mines, Ontario. The government is framing regulations to govern the granting and holding of the corundum lands, which will be put on the market again in a short time.

INFUSORIAL EARTH AND TRIPOLI.

The production of infusorial earth in 1897 amounted to 3,833 short tons, valued at $22,835. This includes the product of the Virginia mines heretofore classed as tripoli. Including this factor, the product in 1896 amounted to 3,846 short tons, with a total value of $26,792 at the point of production and in the first marketable condition. The production of infusorial earth is an irregular industry, and, owing to the fact that the value is in some cases given for the raw material and in other cases at various stages of refinement or manufacture, according to the condition in which it is first marketed, it is not practicable to make any reliable comparisons without betraying the confidential character of individual statements. In the following table it will be observed that a product of 3,466 tons in 1889 was worth $23,372, an average of $6.74 per ton. In the following year 2,532 tons of output was valued at $50,240, an average of nearly $20 per ton. In 1894 the average value per ton had dropped to about $4.50, and to $4.14 in 1895. It advanced to $6.97 in 1896 and dropped again to $5.96 in 1897. And yet there has not been any decided change in the values. These figures indicate the variations in value caused by marketing the product in different conditions.

The amount and value of the product of infusorial earth for the years they have been obtained since 1880 are shown in the following table:

Production of infusorial earth from 1880 to 1897.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1880	1,833	$45,660	1889	3,466	$23,372
1881	1,000	10,000	1890	2,532	50,240
1882	1,000	8,000	1891		21,988
1883	1,000	5,000	1892		43,655
1884	1,000	5,000	1893		22,582
1885	1,000	5,000	1894	2,584	11,718
1886	1,200	6,000	1895	4,954	20,514
1887	3,000	15,000	1896	3,846	26,792
1888	1,500	7,500	1897	3,833	22,835

The porous siliceous rock occurring near Carthage, in Newton County, Missouri, has been classed by the operators as "tripoli." While it answers all the purposes of tripoli so far as polishing qualities are concerned, the name is an erroneous one. It is not infusorial in its origin, but is evidently residual silica, left from an impure siliceous limestone by the leeching out of lime constituents. Its exceeding porosity, and yet compact nature, makes the stone an excellent material for water filters, it being readily cut into any desired shape. It disintegrates easily into a fine powder, the grains of which present sharp cutting edges and form a base for a variety of polishing preparations. The amount of crude rock produced in Newton County in 1897 was 780 tons. Georgia produced 50 tons of tripoli in 1897 against 15 tons in 1896. A small amount (2 tons) was mined in Alabama in the course of development and experimental work.

GARNET.

The production of garnet considered in this chapter refers only to the variety used for abrasive purposes. Ornamental or gem varieties are included in the chapter on precious stones and are not considered here. The localities from which the commercial product of abrasive garnet is obtained are Litchfield County, Connecticut; Essex and Warren counties, New York, and Delaware County, Pennsylvania. The production in 1897 was 2,554 short tons, valued at $80,853, against 2,686 short tons in 1896, worth $68,877, a decrease of 132 tons in quantity and an increase of $11,976 in value. The increase in value in 1897 indicates a slight reaction from the decline shown in the two preceding years. In 1894 the average price per ton for abrasive garnet was $37.76; in 1895 it fell off to $28.59, and again to $25.64 in 1896, recovering somewhat, to $31.66, in 1897. The statistics of abrasive-garnet production were not collected prior to 1894, since when the output has been as follows:

Production of abrasive garnet for four years.

Year.	Short tons.	Value.
1894	2,401	$90,660
1895	3,325	95,050
1896	2,686	68,877
1897	2,554	80,853

QUARTZ CRYSTAL.

Connecticut is credited with the entire product of quartz used for wood finishing. In 1894 this amounted to 6,024 short tons, valued at $18,054. The following year the product was 9,000 tons, worth $27,000; in 1896 it was 6,000 tons, worth $18,000, increasing to 7,500 short tons, worth $22,500, in 1897. The price has remained the same each year. Quartz for this purpose must be very pure and white. It is reduced to an impalpable powder, mixed with oil as in ordinary pigments, and applied to the smooth fresh surface of the wood. The oil penetrates the pores, carrying the fine grains of quartz with it. The quartz fills up the pores of the wood, which is then susceptible of taking a high polish.

Production of quartz crystal since 1894.

Year.	Short tons.	Value.
1894	6,024	$18,054
1895	9,000	27,000
1896	6,000	18,000
1897	7,500	22,500

PUMICE STONE.

The development during 1897 of three deposits of pumice stone, or volcanic ash, in the western part of Nebraska, and another in Millard County, Utah, by the Chicago Pumice Company, announces the first production of this mineral in the United States. The amount of pumice shipped from the four deposits aggregated 158 tons during the year, and up to the 1st of May, 1898, the shipments had reached a total of nearly 600 tons. Heretofore almost the entire demand for pumice has been supplied from Lipari, a small island just north of the island of Sicily, in the Tyrrhenian Sea. There are no records from which even an approximate idea of the amount of this material consumed in the United States can be obtained. The reports to the Bureau of Statistics of the Treasury Department state only the value of the pumice stone imported, no statement of amount being given. During the fiscal year ending June 30, 1897, the value of pumice stone imported into the United States was $65,930. No imports were reported for 1896. In the fiscal year ending June 30, 1895, the pumice stone imported was valued at $47,853; in 1894, $43,788; in 1893, $61,164. About 80 per cent of this comes to this country directly from Lipari. The price, in barrels, of ground and bolted pumice stone at New York is quoted at from 2 to 2½ cents per pound, according to quantity.

During the summer of 1897 one of the United States Geological Survey parties, in making an exploration of the western portion of Nebraska west of the one hundred and third meridian, discovered several very extensive deposits of volcanic ash. They were found to occur at five horizons in the Tertiary formation. Their thickness varies from a few inches to 20 feet, and there is much variability in the degree of purity. The most extensive exposures are in Sioux, Dawes, Scotts Bluff, Banner, and Cheyenne counties. A valuable deposit of ash was also discovered in South Dakota 3 miles east of Pine Ridge Agency. The ash in the Tertiary formations varies considerably in texture and size of grain. Some beds consist of round vesicular grains, with abundant cutting surfaces, but in other beds the ash is in thin flakes, with cutting surface only at the angular edges. The rough, round grains are, of course, much more effective for abrasives than the flaky variety. The character of the material can easily be ascertained by examination under a moderately powerful microscope. The volcanic ash deposits in the Tertiary formations of the western Nebraska regions were brought by the wind from volcanoes probably in Colorado and New Mexico and deposited in the lakes and wide channels which then covered the region. When the winds were strong they carried large amounts of coarser materials, and during times in which the Tertiary beds were not being laid down rapidly there were deposited large volumes of the ash with relatively little admixture of sands and clays.

DEVELOPED DEPOSITS IN NEBRASKA AND UTAH.

In a pamphlet issued by the Chicago Pumice Company the following summary of a report on its properties by Prof. R. D. Salisbury, of the University of Chicago is given:

NEBRASKA.

There are three distinct localities in which the deposits are located. Within each of these three areas there are several more or less closely associated exposures of the pumice. In all places the exposures seem to have much in common. In each instance the pumice appears in the side or at the head of a canyon. In each instance the slope where the pumice is exposed is vertical, or nearly so, though the pumice or volcanic dust does not appear at all points where the slopes are vertical. In all cases the volcanic dust is covered thickly or thinly by a bed of loose material (loess). Thus superficial earth has in many places slipped down the sides of the canyons so as to completely cover their slopes. Where this is true any pumice which may exist in the bluff facing the canyon is concealed.

For the purpose of specification the deposits in Nebraska will be considered by three districts numerically distinguished.

First district.—Elevation, 2,683 feet. The pumice is exposed at four or five points. The most widely separated of these are less than a mile apart. From the proximity of these exposures the first suggestion is that the pumice constitutes a layer beneath the loess throughout the whole area in which the exposures are found, and that it fails of continuous exposure along the canyons only because the loess has slipped down so as to cover it. Further examination shows, however, that this is probably not the fact.

The pumice at several points in the first district is somewhat variable in texture and color. It is sometimes nearly white, sometimes cream color, and sometimes slightly grayish. In grain it varies much; some of it is as coarse as fine sand, and some of it is nearly as fine as flour.

The range of grain is probably not greater than is advantageous, since various grades of coarseness and fineness are desirable for different purposes. These grades of coarseness do not appear to be the result of impurity. So far as can be seen in the field the pumice is essentially pure.

In all places where the pumice is exposed about the first district it can be easily worked. The only preparatory labor that would be necessary would be stripping the upper surface of the loess. Since the loess is incoherent, this would be a simple matter, even though its thickness be considerable.

Second district.—Elevation, 2,127 feet at the railway; at the deposits probably 500 or 600 feet more. This district is about 45 or 50 miles from the first district in a southeasterly direction. The exposures of pumice here are only two in number, but they are much more extensive than those in the first district. The general relations of the exposed deposits at this point are the same as those of the deposits of the first district. They occur along the sides of canyons where the slopes are vertical. Where the slopes have been made gentle by the sliding down of the loess above, no pumice appears. Both exposures in this district occur on the east sides of the canyons.

The pumice in the deposits of this district is more uniform in texture than that in the first district. There is none so coarse as the coarsest in the first district, though there is much which is as fine as any at that locality.

The deposits in this district, while 4 or 5 miles farther from the railroad than those in the first district, are still so situated that a railway track could be run almost to them with a little grading.[1]

All that was said concerning the ease of working the deposits in the first district applies equally well to the deposits of this district.

Third district.—Elevation at railroad, 2,085 feet; at deposits, about 500 feet higher. About 15 miles east-southeast of the second district occurs the exposures in this district, or rather series of exposures, of pumice. The best of these is near the head of a small canyon tributary to the valley leading to the river. Its general relationships are identical with the relationships of the pumice at the other two localities. As there, it is covered by loess, and, as there, it appears only where the slopes are steep, and where the loess has not slumped down from above. The deposit here is not thick, varying from 5 to 12 feet, so far as can be seen. The quality of the pumice here is excellent. It is very fine and very white—the whitest seen. It is exposed at a number of closely associated points, and in such wise as to indicate that it forms a continuous layer throughout the whole of the limited area in which the several exposures occur.

As in other places, the pumice here could be gotten to the railway very easily.

The exposures at all other places are probably not more extensive than the largest exposure in the second district.

UTAH.

The lump pumice stone deposits owned by the Chicago Pumice Company are situated in Utah, and are the only deposits of lump pumice stone known in this country.

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[1] Since above report was made a road has been built directly up the canyon, bringing the railroad within 3 miles of the deposits.

The property consists of 120 acres, which covers the entire deposits, and is secured by land patent from the Federal Government, thus securing absolute title.

The Utah deposit is virtually a mountain of lump pumice stone, of all degrees of quality, entirely free from intruding crystals or other hard substances. It is light, friable, and scoriaceous, and easily obtained. The location of the deposits is within 3 miles of railroad, with gentle down grade from deposits to the road. The quality is excellent and the quantity is inexhaustible. The elevation is about 4,500 feet above the sea level. The surrounding country is barren, with scarcely any population within 25 or 30 miles. Very little vegetation except sage brush, though the valley land is fertile if sufficient moisture were obtainable. In the mountains, some 30 miles to the east, timber is abundant.

As before stated, the pumice is easily secured; in fact, quarrying is the proper method to be employed, as one leg of the mountain is a continuous deposit of lump pumice stone. Pieces from the size of a fist to the size of a large cask are obtained, and the many pieces subjected to test show the same purity. They are friable, free from any hard substances, and contain nothing but the true substance—pumice.

The following analyses of the Nebraska and Utah pumice have been made:

Analyses of Nebraska and Utah pumice.

[Analysts: William Koehler, Cleveland, Ohio; Frank E. Mariner, Chicago, Ill.; Mr. Jackson, Washington, D. C.]

	First district.	Second district.	Third district.
	Per cent.	*Per cent.*	*Per cent.*
Water	4.45	5.22	4.09
Silica	71.25	70.10	74.32
Alumina	11.75	12.13	12.47
Oxide of iron	2.00	2.06	1.75
Lime	2.25	1.62	.89
Potash and soda	7.32	8.51	8.44

[Analyst: W. H. Andrews, Ann Arbor, Mich.]

	Second district, Nebr.	Utah pumice.
	Per cent.	*Per cent.*
Silica	71.97	72.58
Alumina	14.86	15.66
Ferric oxide	.88	.96
Lime	.77	.73
Soda and potash	8.28	8.28
Loss by ignition	3.64	3.64

CARBORUNDUM.[1]

The production of carborundum during 1897 amounted to 621 short tons of crystalline production, having a value of $153,812. There were also produced 47 tons of amorphous carborundum, having a value of $940.

The consumption of carborundum in the manufacture of grinding wheels increased rapidly during the year, as the direct result of improvement in their manufacture, decrease in selling price, and more extended knowledge of the merits of the material, resulting in more than doubling the value of the sales.

Carborundum was introduced very extensively into the steel-ball grinding industry during the year. Experiments made with carborundum mounted on belts, as emery is mounted, were not very encouraging, as the great hardness and sharpness of the material caused the grains to be pulled from their mounting before accomplishing much work. The attempts to make carborundum cloth and paper in the emery, garnet, and flint paper manufactories were more successful.

The most important development of the year, however, has been the advance made in the use of carborundum (carbide of silicon) in steel making. As early as 1893, metallurgists, not only in this country but also in England and Germany, saw the great advantage of substituting carbide of silicon for ferrosilicon in steel making. The carbide of silicon is absolutely free from sulphur, phosphorous, and other deleterious elements which have to be so carefully controlled or guarded against by the steel makers. It carries, moreover, from 60 to 65 per cent of silicon, the remainder being principally free from carbon, with a trace of lime and alumina. Ferrosilicon contains but from 10 to 15 per cent of silicon, and is never free from phosphorous or sulphur.

The experiments thus early begun were carried to a successful finish, so that, as the year closed, several large steel manufactories introduced the new material into their works, and the indications were that another year would witness a very general change from ferrosilicon to carbide of silicon in the larger steel plants of the country.

The development of the use of carborundum in steel making brought to light a point of more than ordinary interest, and particularly so from a scientific view. It was discovered that the amorphous variety of carborundum was insoluble in melted steel or iron, whereas the crystalline form was known to dissolve with great ease under similar conditions. This would seem to indicate that the solubility of the carborundum in melted steel is closely associated with its physical form, as both varieties are of identically the same chemical composition.

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[1] By E. G. Acheson, president, Carborundum Company.

PHOSPHATE ROCK.

PRODUCTION.

The total quantity of phosphate rock produced in the United States has been without considerable variation since 1893. In that year the total product was 941,368 long tons, and was divided in nearly equal amounts between Florida and South Carolina. In 1897 the total product was 1,039,345 long tons, and divided between Florida, South Carolina, and Tennessee. The proportion from Florida had gained about one-fourth—from 438,804 long tons in 1893 to 552,342 long tons in 1897. Tennessee and South Carolina produced together about as much as was furnished by South Carolina alone in previous years. Thus in 1897 the total from South Carolina was 358,280 long tons, and from Tennessee 128,723 long tons. The most significant change in the industry aside from this extension of the productive field to include the important deposits of Maury County, Tennessee, has been the great decrease in price. Thus, while the total quantity was a few tons larger than in any previous year, its total value was less than in any other recent year. The statistics are summarized in the table which follows:

Product of phosphate rock from 1891 to 1897.

State.	1891.		1892.	
	Quantity.	Value.	Quantity.	Value.
Florida:	*Long tons.*		*Long tons.*	
Hard rock	57,982	....	a155,908	$859,276
Soft rock			6,710	32,418
Land pebble			21,905	111,271
River pebble	54,500	....	b102,820	415,453
Total	112,482	$703,013	287,343	1,418,418
South Carolina:				
Land rock	344,978	2,187,160	243,653	1,236,447
River rock	130,528	760,978	150,575	641,262
Total	475,506	2,948,138	394,228	1,877,709
Grand total	587,988	3,651,151	681,571	3,296,127

a Includes 52,708 tons of hard rock carried over in stock from 1891.

b Includes 12,120 tons of river pebble carried over in stock from 1891.

Product of phosphate rock from 1891 to 1897—Continued.

State.	1893.		1894.	
	Quantity.	Value.	Quantity.	Value.
Florida:	*Long tons.*		*Long tons.*	
Hard rock	215,685	$1,117,732	326,461	$979,383
Soft rock	13,675	64,626	....	....
Land pebble	86,624	359,127	98,885	296,655
River pobble	122,820	437,571	102,307	390,775
Total	438,804	1,979,056	527,653	1,666,813
South Carolina:				
Land rock	308,435	1,408,785	307,305	1,252,768
River rock	194,129	748,229	142,803	492,808
Total	502,564	2,157,014	450,108	1,745,576
Tennessee	....	....	19,188	67,158
Grand total	941,368	4,136.070	996,949	3,479,547

State.	1895.		1896.		1897.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Florida:	*Long tons.*		*Long tons.*		*Long tons.*	
Hard rock	307,098	$1,302,096	296,811	$1,067,525	360,147	$1,063,713
Soft rock	6,916	32,000	400	2,300	2,300	4,600
Land pebble	181,011	593,716	97,936	176,972	92,132	180,794
River pebble	73.036	185,090	100,052	300,556	97,763	244,408
Total	568,061	2,112,902	495,199	1,547,353	552,342	1,493,515
South Carolina:						
Land rock	270,560	898,787	267,072	792,457	267,380	748,050
River rock	161,415	512,245	135,351	389,192	90,900	238,522
Total	431,975	1,411,032	402,423	1,181,649	358,280	986,572
Tennessee	38,515	82,160	26,157	57,370	128,723	193,115
North Carolina	....	....	7,000	17,000	....	....
Grand total	1,038,551	3,606,094	930,779	2,803,372	1,039,345	2,673.202

FLORIDA.

By the enterprise of Messrs. Auchincloss Brothers, New York, the following statistics in regard to the shipments of hard-rock phosphate from Florida are presented:

Total shipments of Florida hard-rock phosphate, by months, since 1894.

[Long tons.]

Month.	1897.	1896.	1895.	1894.
January	12, 924	16, 996	15, 780	16, 526
February	20, 668	16, 853	17, 252	4, 111
March	37, 243	37, 155	31, 283	34, 126
April	32, 608	36, 559	41, 445	36, 533
May	45, 715	45, 846	45, 053	30, 780
June	32, 837	16, 511	31, 027	29, 818
July	22, 639	15, 296	21, 284	46, 855
August	19, 292	19, 914	14, 588	37, 823
September	59, 966	25, 116	25, 388	34, 032
October	27, 664	30, 605	27, 783	19, 732
November	20, 184	38, 402	18, 160	7, 683
December	18, 537	23, 618	17, 003	6, 060
Total shipments	350, 277	322, 871	306, 046	304, 079

Shipments of hard-rock phosphate, by countries.

[Long tons.]

Country.	1897.	1896.	1895.	1894.
England	24, 163	20, 533	27, 007	45, 455
Scotland	5, 957	1, 038	3, 054	8, 144
Ireland	2, 953	513	3, 867	6, 737
Germany	181, 355	151, 461	145, 377	153, 526
Belgium	22, 954	27, 214	7, 033	....
Holland	53, 039	47, 235	52, 724	47, 465
Denmark	11, 019	9, 594	6, 735	7, 726
Norway and Sweden	7, 442	12, 534	9, 304	7, 940
France	13, 931	6, 986	23, 534	12, 101
Italy	16, 931	32, 999	21, 615	13, 810
Russia	3, 613	1, 607	....	....
Austria	4, 505	2, 494	3, 871	700
United States, West Indies, etc.	2, 415	8, 663	1, 925	475
Total shipments	350, 277	322, 871	306, 046	304, 079

The shipments to Holland in the above statement might properly be assigned to Germany, as a large proportion of the receipts at Rotterdam are forwarded to the interior of Germany.

The following are the details of all shipments to each port:

Destination of shipments of hard-rock phosphate, by ports.

[Long tons.]

Port.	1897.	1896.	1895.	1894.
UNITED KINGDOM.				
London	9,058	6,382	7,071	13,970
Liverpool	11,295	8,423	6,475	3,053
Birkenhead	....	2,442	2,446	5,724
Garston	....	....	4,706	16,987
Hull	....	1,130	....	....
Newcastle	2,316	2,156	4,363	5,721
Bonnes	....	....	....	2,838
Glasgow	2,174	....	2,209	2,070
Aberdeen	1,495	1,038	845	836
Dublin	1,476	513	1,548	3,689
Cork	1,477	....	1,218	1,076
Belfast	....	....	1,101	1,972
Leith	2,288	....	....	2,400
Ipswich	1,494	....	....	....
Felixstowe	....	....	850	....
Silloth	....	....	1,096	....
Total	33,073	22,084	33,928	60,336
BALTIC.				
Aarhuus	4,917	3,217	773	2,118
Kastrup	6,102	6,377	5,962	5,608
Landskrona	3,110	8,441	2,952	2,680
Gothenburg	1,285	2,771	3,927	2,630
Stockholm	3,047	1,322	2,425	2,630
Stettin	63,437	60,977	55,016	46,380
Danzig	....	2,215	1,842	4,331
Memel	10,135	2,981	4,200	2,184
Friederichstadt	....	....	3,819	....
Riga	....	1,607	....	....
Libau	3,613	....	....	....
Total	95,646	89,908	80,916	68,561
CONTINENTAL.				
Rotterdam	50,548	42,204	52,724	47,465
Antwerp	8,716	14,632	2,805	....
Ghent	14,238	12,582	1,818	....
Hamburg	82,765	58,772	62,975	61,712
Harburg	5,378	10,789	12,894	24,297
Bremen	19,640	13,700	1,653	....
Gerstemunde	....	2,027	2,978	14,622

Destination of shipments of hard-rock phosphate, by ports—Continued.

[Long tons.]

Port.	1897.	1896.	1895.	1894.
CONTINENTAL—continued.				
La Pallice	2,740		75,692	
Delfzyl		1,738		
Dordrecht		3,293		
Ostend			2,410	
Bordeaux				2,953
Tonnay Charente				1,025
Zwyndrecht	2,491			
Total	186,516	159,737	145,949	152,074
MEDITERRANEAN.				
Cette	7,746		6,055	1,132
St. Louis du Rhone	2,354	3,207	9,159	6,991
Marseilles	1,091		2,030	
Venice	5,310	10,272	7,888	2,181
Genoa	11,621	21,632	13,227	11,629
Galatz		2,494		
Fiume	2,705		3,871	700
Port de Bouc		1,458		
Leghorn		3,416		
Trieste	1,800			
Bone			1,098	
Total	32,627	42,479	43,328	22,633
DOMESTIC, ETC.				
Cartaret	2,415	2,950		
Baltimore		292	1,920	
Elizabethport		1,920		
Philadelphia		3,001		
New York			5	
Barbados, West Indies		500		475
	2,415	8,663	1,925	475
RECAPITULATION.				
United Kingdom	33,073	22,084	33,928	60,336
Baltic ports	95,646	89,908	80,916	68,561
Continental ports	186,516	159,737	145,949	152,074
Mediterranean ports	32,627	42,479	43,328	22,633
Total foreign shipments	347,862	314,208	304,121	303,604
Domestic shipments	2,415	8,663	1,925	475
Total shipments	350,277	322,871	306,046	304,079

These statistics show a well distributed and substantial increase of shipments over those of 1896, notwithstanding decreased production, and there is reasonable prospect of an increased use during 1898.

During 1897 the continued and severe depression in prices has been most disastrous to the Florida high-grade rock industry. Of the companies in existence on January 1, 1897, a considerable number disappeared during the year, having completely abandoned all operations, owing either to exhaustion of deposits or exhaustion of funds, through losses incurred in operation. Over one-half of the mines or pits that had been opened since the beginning of the industry in 1890 are now exhausted and abandoned, and the process of abandonment has been accentuated during the past year. Of the 252 corporations or individuals who organized to engage in high-grade rock mining in Florida since the commencement of the industry in 1890 to December 31, 1897, 28 corporations or individuals are at present actively operating high-grade rock mines in Florida; 41 companies were organized for mining purposes, but failed before mining operations were commenced; and 183 commenced mining but became financially unsuccessful and abandoned operations. Of these 183 companies, 135 have abandoned operations in consequence of the exhaustion of their mines or pits.

The stock of phosphate above ground, ready for shipment, steadily decreased during the year, and on January 1, 1898, it was equal only to 50 per cent of the stock on hand and ready for shipment January 1, 1897. The average monthly production of high-grade rock in Florida during 1897 was less than 80 per cent of the average monthly shipments.

During 1897 the Florida high-grade rock industry has, under the pressure of extremely low prices, been steadily adjusting itself to the demand, and the restriction of available, easily worked deposits, the decreased stock on hand, the decreased rate of production, and the increased rate of shipments indicate that the business is emerging from the unhealthy conditions so long prevalent.

Messrs. Auchincloss Brothers point out that a large number of the mining plants in Florida have been and are now closed in consequence of low prices. It is argued by some that should any decided improvement in price occur these closed companies would again resume mining and another period of overproduction ensue. But it should be noted that a majority of the plants in question have been closed for a period of at least two years. A considerable number have closed owing to exhaustion of their deposits, and can not, therefore, start again in the same locations, but must be moved to new deposits. Many others are closed owing to financial difficulties, but in every instance, in consequence of the semitropical climatic conditions of Florida, so destructive to wooden structures, a majority of the plants at present closed are so rotted that they would require complete rebuilding before they could be put into condition for operation. It will require a considerable advance in price before attempts will be made to operate many of the mining plants at present idle, and the mining must also be shown to be reasonably profitable and permanent before new capital can be induced to undertake to resuscitate what are at present acknowledged failures.

The following statistics in regard to the shipments of pebble phosphate are also furnished by Messrs. Auchincloss Brothers:

Shipments of Florida pebble phosphate from 1894 to 1897.

[Long tons.]

Ports.	1897.	1896.	1895.	1894.
UNITED KINGDOM.				
London	....	1,138	7,860	12,200
Liverpool	....	....	....	2,500
Birkenhead	6,576	3,972	....	1,016
Garston	2,739	....	2,261	4,200
Newcastle	....	....	....	2,525
Bonnes	....	....	....	4,736
Glasgow	2,377	....	3,360	1,813
Aberdeen	1,000	1,582	2,186	....
Dublin	....	1,021	2,061	9,476
Belfast	3,158	2,576	3,873	....
Leith	....	....	....	2,550
Plymouth	7,408	4,623	8,921	8,430
Kingslynn	13,046	9,019	12,003	5,491
Falmouth	1,830	1,200	....	900
Swansea	1,250	819	....	1,817
Bristol	6,000	1,813	2,724	4,619
Ipswich	....	4,529	3,956	3,644
Drogheda	....	2,694	....	....
Newport	3,000	....	....	....
Felixstowe	....	....	....	2,250
Exmouth	....	....	710	....
Padstow	....	....	436	....
Monmouth	....	....	2,574	....
Harwich	....	2,045	....	....
Total	48,384	37,031	52,925	68,167
BALTIC.				
Gothenburg	....	2,220	9,503	....
Stettin	5,309	2,760	7,704	24,818
Memel	....	1,500	....	....
Riga	....	5,511	2,613	....
Helsingborg	14,834	6,634	5,795	8,412
Mühlgraben	2,500	....	....	....
Total	22,643	18,625	25,615	33,230

Shipments of Florida pebble phosphate from 1894 to 1897—Continued.

[Long tons.]

Ports.	1897.	1896.	1895.	1894.
CONTINENTAL.				
Rotterdam	....	....	5,743	....
Antwerp	....	....	....	2,700
Hamburg	4,001	4,876	18,877	17,757
Harburg	6,405	5,461	6,532	4,374
Bremen	....	2,465	....	....
La Pallice	....	2,180	....	....
Delfzyl	....	....	....	1,600
Nantes	2,092	2,282	2,045	....
Bordeaux	2,753	5,040	1,611	....
Port de Bouc	....	1,204	....	....
Granville	....	....	....	2,289
St. Nazaire	....	2,802	....	....
Rendsburg	2,175	....	....	....
Total	17,426	26,310	34,808	28,720
MEDITERRANEAN.				
Cette	....	....	258	....
St. Louis du Rhone	....	....	5,298	....
Genoa	1,160	....	1,005	2,950
Fiume	....	....	....	6,209
Total	1,160	....	6,561	9,159
DOMESTIC, ETC.				
Cartaret	28,728	15,278	18,890	12,412
Baltimore	48,936	38,737	26,804	30,479
Elizabethport	827	....	....	....
Philadelphia	11,526	5,308	12,962	7,322
New York	....	5,113	3,230	3,274
Newtown Creek	618	....	....	1,573
Mantua Creek	1,752	2,473	....	1,150
Alexandria	4,051	969	....	....
Wilmington	8,057	6,620	....	1,930
Mobile	1,415	1,725	....	1,220
Savannah	....	....	1,876	....
Richmond	4,908	4,406	....	....
Norfolk	11,918	6,235	....	....
Pensacola	....	1,956	918	2,050
New Orleans	....	4,743	....	2,160
City Point	....	....	....	2,154
Total	122,736	93,563	64,680	65,724

Shipments of Florida pebble phosphate from 1894 to 1897—Continued.

[Long tons.]

Ports.	1897.	1896.	1895.	1894.
RECAPITULATION.				
United Kingdom	48,384	37,031	52,925	68,167
Baltic ports	22,643	18,625	25,615	33,230
Continental ports	17,426	26,310	34,808	28,720
Mediterranean ports	1,160	....	6,561	9,159
Total foreign shipments	89,613	81,966	119,909	139,276
Domestic shipments	122,736	93,563	64,680	65,724
Total shipments	212,349	175,529	184,589	205,000
River pebble.				
Foreign shipments	51,140	45,712	56,552	90,054
Domestic shipments	50,259	27,708	5,945	15,770
Total shipments	101,399	73,420	62,497	105,824
Land pebble.				
Foreign shipments	38,473	36,254	63,357	49,222
Domestic shipments	72,477	65,855	58,735	49,954
Total shipments	110,950	102,109	122,092	99,176

The conditions of phosphate mining in the pebble region are well shown by the following report of Mr. C. G. Memminger:

REVIEW OF THE LAND AND RIVER PEBBLE PHOSPHATE MINING INDUSTRY FOR THE YEAR 1897.

Land pebble mining.—While no radical change has been made in the system of mining and milling, there has been a marked improvement in general methods, the miners having been forced by low prices of phosphate to a more perfect system of raising and preparing their product. Considerable improvements have been made in the construction of centrifugal pumps, and a pump has been evolved that answers every requirement of the work. A combination of a rotary and flat screen for the first separation of the pebble has proved excellently adapted for this purpose. A decided improvement is also shown in the rubber hydraulic and suction hose. The former hydraulic hose was wrapped outside with flat spiral steel bands. This wrapping soon became displaced and quickly rusted out. A 10-ply 8-inch hose is now made with the steel spiral in the center, 5 plies on either side. This hose wears well and readily stands hydraulic pressure of 150 to 175 pounds. The adoption of compound condensing pumps will be another step in the direction of economy, and probably the coming year will see some advance along this line, as the question of fuel economy is daily becoming more urgent.

The adoption of a furnace in connection with the rotary drier, in which the pebble passes down an inclined plane in direct contact with the flame, is a notable improvement. The rotary cylinder drier is raised to a height of 12 to 15 feet; a furnace is constructed at the end of the cylinder and so arranged that the material, after passing through the cylinder, runs down a slope 14 feet in length, backed with a special fire tile; and the furnace is so constructed that the full force of the flame passes up the incline, and as the pebble drops down it is subjected to intense heat. These driers have also greater capacity and are much more economical than the original cylinder drier without improved furnace. There were in all twenty-two plants constructed for land pebble mining. Of these a number were built prior to the introduction of the hydraulic mining system, and their methods of mining proved a failure. In other cases plants were erected on deposits that were not workable, either from lack of quantity or inferior quality, and others were simply wild-cat speculations. At present there are but four land pebble mining companies in operation.

The production of land pebble for the year 1897 was a little over 92,000 tons.

River pebble mining.—The Peace River mining territory is now controlled by the Peace River Consolidated Phosphate Company. This company has its own railroad, 25 miles in length, terminals, lighters, tugs, etc., for transportation from its mines to vessels at Boca Grande.

The same general system of mining is pursued as formerly, except that the mining is carried on in the swamp adjoining the river course, the pebble in the river bed proper being exhausted. The cost of river pebble has been reduced to a minimum, first, by the company controlling its own transportation, and, secondly, by the perfect system of handling the pebble. Stations known as "hoists" are located at points along the river convenient to the place where mining is being carried on. The pebble is pumped up by the dredges and loaded on lighters, and these lighters are unloaded at the hoists by elevators, the pebble transferred to cars, and transported in these cars to the central drying plant. The plant is so arranged that cars dump directly into the wet bin, from this bin it passes on to the driers, and thence into the dry storage bins. The dry bins are elevated to a convenient height for specially constructed cars to run under the bins, and the pebble is loaded into the cars and transported to the lighters and thence to the vessels.

The labor item is reduced to a minimum, as the pebble is handled throughout by machinery. The improved furnace in connection with the rotary drier before described was first used by the river miners, and they have continued its use in the most improved form.

River mining on the Alafia River has entirely ceased.

The output of river pebble for 1897 was not quite 100,000 tons.

Market.—Low prices for phosphate still continue, and the close of 1897 showed a weak market, with prices lower than those of the preceding year. It is, however, unquestionably a fact that prices have reached the lowest limit possible. The cost of production can not be materially reduced, and pebble is now being sold at actual cost. This abnormal condition can not be maintained, and if prices do not advance the mines must eventually close.

SOUTH CAROLINA.

The total production of phosphate rock in South Carolina since 1867 and the distribution of the shipments are shown in the following table:

Phosphate rock mined by the land and river mining companies of South Carolina.

Year ending—	Land companies.	River companies.	Total.
May 31—	*Long tons.*	*Long tons.*	*Long tons.*
1867	6	....	6
1868	12, 262	....	12, 262
1869	31, 958	....	31, 958
1870	63, 252	1, 989	65, 241
1871	56, 533	17, 655	74, 188
1872	36, 258	22, 502	58, 760
1873	33, 426	45, 777	79, 203
1874	51, 624	57, 716	109, 340
1875	54, 821	67, 969	122, 790
1876	50, 566	81, 912	132, 478
1877	36, 431	126, 569	163, 000
1878	112, 622	97, 700	210, 322
1879	100, 779	98, 586	199, 365
1880	125, 601	65, 162	190, 763
1881	142, 193	124, 541	266, 734
1882	191, 305	140, 772	332, 077
1883	219, 202	159, 178	378, 380
1884	250, 297	181, 482	431, 779
1885	225, 913	169, 490	395, 403
December 31—			
1885 (*a*)	149, 400	128, 389	277, 789
1886	253, 484	177, 065	430, 549
1887	261, 658	218, 900	480, 558
1888	290, 689	157, 878	448, 567
1889	329, 543	212, 102	541, 645
1890	353, 757	110, 241	463, 998
1891	344, 978	130, 538	475, 516
1892	243, 652	150, 575	394, 227
1893	308, 435	194, 129	502, 564
1894	307, 305	142, 803	450, 108
1895	270, 560	161, 415	431, 975
1896	267, 072	135, 351	402, 423
1897	267, 380	90, 900	358, 280
Total	5, 442, 962	3, 469, 286	8, 912, 248

a Seven months.

In the following tables will be found statements of the shipments of South Carolina phosphate rock since 1874 and the product of the State from 1867 to 1897:

Detailed statement of total foreign and coastwise shipments and local consumption of South Carolina rock since June 1, 1874.

[Long tons.]

Period.	Shipments and consumption.	Beaufort.	Charleston.	Total.	Total for each year.
June 1, 1874, to May 31, 1875..	Foreign ports...	44,617	25,929	70,546	122,790
	Domestic ports .	7,000	25,560	32,560	
	Consumed	....	19,684	19,684	
June 1, 1875, to May 31, 1876..	Foreign ports...	50,384	25,431	75,815	132,896
	Domestic ports .	9,400	28,831	38,231	
	Consumed	....	18,850	18,850	
June 1, 1876, to May 31, 1877..	Foreign ports...	73,923	28,844	102,767	163,220
	Domestic ports .	6,285	40,768	47,053	
	Consumed	....	13,400	13,400	
June 1, 1877, to May 31, 1878..	Foreign ports...	100,619	21,123	121,742	208,323
	Domestic ports .	8,217	60,729	68,946	
	Consumed	....	17,635	17,635	
June 1, 1878, to May 31, 1879..	Foreign ports...	97,799	21,767	119,566	199,365
	Domestic ports .	8,618	52,281	60,899	
	Consumed	....	18,900	18,900	
June 1, 1879, to May 31, 1880..	Foreign ports...	47,157	14,218	61,375	190,763
	Domestic ports .	13,346	94,002	107,348	
	Consumed	....	22,040	22,040	
June 1, 1880, to May 31, 1881..	Foreign ports...	62,200	8,568	70,768	266,734
	Domestic ports .	65,895	91,929	157,824	
	Consumed	....	38,142	38,142	
June 1, 1881, to May 31, 1882..	Foreign ports...	89,581	22,905	112,486	332,077
	Domestic ports .	65,340	111,314	176,654	
	Consumed	....	42,937	42,937	
June 1, 1882, to May 31, 1883..	Foreign ports...	94,789	28,251	123,040	378,380
	Domestic ports .	62,175	150,545	212,720	
	Consumed	....	42,620	42,620	
June 1, 1883, to May 31, 1884..	Foreign ports...	132,114	20,539	152,653	431,779
	Domestic ports .	41,040	181,363	222,403	
	Consumed	5,800	50,923	56,723	
June 1, 1884, to May 31, 1885..	Foreign ports...	111,075	11,495	122,570	395,403
	Domestic ports .	44,130	161,700	205,833	
	Consumed	12,000	55,000	67,000	
June 1, 1885, to Dec. 31, 1885..	Foreign ports..	105,761	8,581	114,342	277,789
	Domestic ports .	16,321	112,126	128,447	
	Consumed	5,000	30,000	35,000	
Jan. 1, 1886, to Dec. 31, 1886..	Foreign ports...	153,443	5,926	159,369	430,549
	Domestic ports .	14,622	187,558	202,180	
	Consumed	9,000	60,000	69,000	
Jan. 1, 1887, to Dec. 31, 1887..	Foreign ports...	189,995	9,740	199,735	480,558
	Domestic ports	15,905	181,918	197,823	
	Consumed	13,000	70,000	83,000	
Jan. 1, 1888, to Dec. 31, 1888..	Foreign ports...	124,474	3,611	128,085	448,567
	Domestic ports .	20,404	212,078	232,482	
	Consumed	13,000	75,000	88,000	
Jan. 1, 1889, to Dec. 31, 1889..	Foreign ports...	137,102	5,900	143,002	541,645
	Domestic ports .	60,000	248,643	308,643	
	Consumed	15,000	75,000	90,000	

Detailed statement of total foreign and coastwise shipments and local consumption of South Carolina rock since June 1, 1874—Continued.

[Long tons.]

Period	Shipments and consumption.	Beaufort.	Charleston.	Total.	Total for each year.
Jan. 1, 1890, to Dec. 31, 1890..	Foreign ports...	72,241	55,000	127,241	463,998
	Domestic ports .	15,000	213,757	228,757	
	Consumed	13,000	85,000	98,000	
Jan. 1, 1891, to Dec. 31, 1891..	Foreign ports...	94,528	4,655	99,183	475,516
	Domestic ports .	22,000	252,083	274,083	
	Consumed	14,000	88,250	102,250	
Jan. 1, 1892, to Dec. 31, 1892 .	Foreign ports...	105,150	5,052	110,202	394,227
	Domestic ports .	30,425	148,600	179,025	
	Consumed	15,000	90,000	105,000	
Jan. 1, 1893, to Dec. 31, 1893..	Foreign ports...	156,257	175	156,432	502,564
	Domestic ports .	22,872	160,942	183,814	
	Consumed	15,000	147,318	162,318	
Jan. 1, 1894, to Dec. 31, 1894..	Foreign ports...	114,155	12,417	126,572	450,108
	Domestic ports .	21,000	154,853	175,853	
	Consumed	12,683	135,000	147,683	
Jan. 1, 1895, to Dec. 31, 1895..	Foreign ports...	114,430	10,090	124,520	431,975
	Domestic ports .	9,500	155,855	165,355	
	Consumed	12,100	130,000	142,100	
Jan. 1, 1896, to Dec. 31, 1896..	Foreign ports...	113,351	12,000	125,351	402,423
	Domestic ports .	12,000	130,072	142,072	
	Consumed	10,000	125,000	135,000	
Jan. 1, 1897, to Dec. 31, 1897..	Foreign ports...	75,108	1,300	76,408	358,280
	Domestic ports .	10,000	129,872	139,872	
	Consumed	12,000	130,000	142,000	

TENNESSEE.

The following report by Mr. Lucius P. Brown shows the development of the industry in Tennessee, and especially of the new Maury County district:

THE PHOSPHATE ROCK DEPOSITS OF TENNESSEE DURING 1897.

MOUNT PLEASANT DISTRICT.

In considering this subject it seems best to take up the three distinct and separate fields in the order of their relative importance. The Mount Pleasant field, therefore, first engages our attention. The existence of valuable deposits in this district was first discovered by S. Q. Weatherly, of Palestine, Lewis County, in January, 1896. For business reasons no effort was at that time made to develop them, but about July 15 of that year work was begun in mining, and has since that time steadily progressed. The first mining done was in the town of Mount Pleasant, which has given its name to the field. This place is in Maury County, 11 miles southwest of the county seat, Columbia, on the Nashville, Florence and Sheffield Railroad, a branch of the Louisville and Nashville system. Although it lies in one edge of the field it is the center of operations in the district. The field itself is about 4 by 6 miles in extent, with the long diameter approximately perpendicular to the line of the railway. It probably does not extend more than a mile to the west of the railway and about 5 miles to the east of it. Except where erosion, in the valleys of the branches and creeks, has reduced the level of the country below the phosphate horizon, practically all this area is underlaid by phosphate deposits of varying thickness and degrees of richness.

Geologically this deposit is of Lower Silurian age, belonging in the Capitol limestone, a member of the Nashville (Cincinnati) formation. The Nashville beds are thus described by Dr. J. M. Safford, the numbering beginning at the bottom:

> (1) The Orthis bed, about 60 feet thick, represents a horizon easily recognized throughout the Silurian Basin of middle Tennessee. Its distinctive characteristics, some of its layers usually being made up wholly of shells of *Orthis testudinaria*, make it an excellent guide rock for the next formation, which is—
>
> (2) The Capitol limestone, a granular, current-formed, and hence laminar limestone, showing cross-stratification. The average thickness may be placed at about 60 feet.
>
> (3) The Dove limestone, 10 to 12 feet in thickness, mostly a compact, dove-colored limestone.
>
> (4) Upon the Dove lies the Ward limestone, 28 feet thick, parts of which are much like the Capitol limestone, laminated, and showing current action.

All these rocks are more or less phosphatic, but it is the Capitol division which is the great source of the phosphate, and the thickness of workable beds in this averages about 6 feet.

It is hardly to be doubted that the origin of all the phosphate of the Mount Pleasant district, with an exception to be noticed later, lies in the leaching of certain highly phosphatic limestone. This leaching has come from the long-continued action of atmospheric waters sinking through the soil, dissolving and carrying away the comparatively soluble calcium carbonate, and leaving behind the less soluble phosphate. This, however, does not account for the origin of what is known as "hard rock." This has been found, so far as is known, only at one point, in very small amount, and is interesting in the main only from a geologic standpoint. It is of as close a texture as the oolitic Devonian phosphate, light cream in color, showing in the mass rose-colored streaks and concentric rose-colored circles several inches apart, at the center of which is a mass of blue rock of varying size, but usually comparatively small. The structure clearly indicates that the whole rock was originally blue, of exactly the character of the central mass, and that the buff or cream color and concentric rosy rings are the result of weathering. The origin of this hard rock is probably the same as that of the phosphatic limestone from which the main body of the deposit was derived, modified in chemical character by local conditions as yet unexplained.

The phosphatic limestone is usually slaty-blue in color and granular and firm in texture, containing nearly 50 per cent of phosphate of lime.[1]

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[1] See table of analyses, p. 551.

The color is probably due to organic matter, and on weathering changes first to a light pearl-gray and then to a dirty light brown or gray. Its origin is difficult to account for, as it seems to be essentially a local change in the character of the phosphate stratum, which is found wherever the Capitol limestone occurs throughout middle Tennessee, but is usually of very different character. Information on this subject is needed, and there is an opportunity for some good work in ascertaining the cause of the changes in this stratum as well as in that of the Devonian phosphate. It is probable that the same causes operated in each case. Although of such wide distribution, only at a very few points outside the Mount Pleasant district is the phosphate stratum of sufficiently high grade to justify mining. This means that the rock must contain not less than 70 per cent phosphate of lime; of lower grade material, particularly of rock less than 60 per cent, there is an enormous amount throughout this region. The rock loses value in phosphoric acid by an admixture of sand or clay, and at some points, as in the southern edge of Maury County, where the deposit is very thick, it becomes a sandstone carrying only 4 or 5 per cent of phosphate of lime. In the Lower Silurian regions of central Kentucky very much the same rock has been observed, but in small amount.[1] The presence of this and similar materials accounts for the lasting qualities of the agricultural lands where it is found both in Kentucky and Tennessee.

For all practical purposes, as mentioned above, it may be considered that there is only one variety of Mount Pleasant rock. This rock is in color grayish or reddish brown to creamy white, very porous, soft, and light, and occurs in plates of varying thickness and size, but rarely more than a few hundred pounds in weight. These plates are packed closely together into stratum resembling a loosely built wall of dry masonry. This follows more or less closely the contour of the surface, but is not always of the same thickness, changes in the limestone bottom, or rather differences of weathering in the original limestone, modifying this characteristic. A cubic yard of rock in the bank yields about 1,400 pounds of merchantable rock. The overburden consists only of loose earth and fully disintegrated phosphates, and varies from an inch or two to 3 or 4 feet in thickness, except in the eastern portion of the field, where it becomes so great as to preclude its profitable removal, and its nature apparently renders underground mining impracticable. Toward the eastern limits the field also rises much higher above the hydraulic level than is the case near Mount Pleasant.

Methods of mining.—All mining is done by hand, machinery being impracticable, and is all open-cut work. The procedure may be said to be about as follows: The ground having first been thoroughly prospected, and after a mill (if one is built), dry sheds, tram tracks, etc., are completed, actual mining operations are begun by stripping the overburden for, say, 100 feet back from the outcrop, or from the main tram track, as the case may be. This may be done by hand, but scrapers are preferable. The mining force then works with only picks, shovels, and crowbars, until a long working face is established. This gives room for the economical employment of a large force if so desired. The mining practice and the preparation of the rock for market vary somewhat in the different mines, and are as yet in a measure tentative, but the methods of one of the best-equipped plants in the field are as follows: As the face is advanced spurs from the main tram tracks keep pace with it, the car being pushed right against the face, leaving room only for the miner to work. No blasting is necessary, except occasionally to remove a limestone "chimney" in extending the track, the rock yielding easily to assaults upon it with pick and crowbar. The rock as mined is divided into two classes, "lump" and "muck." The former goes directly to the dry kilns, and the latter, consisting of the smaller pieces of rock, "spalls," etc., is trammed to a washer, where a powerful stream of water from an hydraulic is turned on it, washing out through a screen the earth and finest material. What fails to pass this screen is then elevated and passed over a screen with 2½-inch mesh. The screenings from this are carried (in trams) to a special kiln and dried; the rock larger than 2½ inches goes to the same kilns as "lump." These kilns are built under a shed and are on a lower level than the mine tracks. The latter, being extended to the top of the sheds, serve to allow the cars loaded with mine rock to be run in above the kilns and dumped, obviating one handling. The kilns themselves are essentially the same as are used in Florida for drying "hard rock," being simply a pile of cord wood constructed in the desired shape, upon which the rock is dumped. No machine dryers have thus far been used. The dry sheds are built large enough to accommodate several kilns, so that mining operations may not be interrupted. The kilns, of course, may be of any desired size, but the average contains about 300 tons. The complete burning of the wood takes about twenty-four hours, and about sixty hours after firing the rock is ready to draw. It is then conveyed to the crusher, the top of which is on a level with the floor of the kilns. Here it is reduced to about a 4-inch size, and goes next to a series of screens into which also the "muck" less than 2½ inches is passed. By a system of sizing and recrushing a portion of the material the rock is divided into three grades. The 3-inch and above is the highest grade, containing least iron and aluminum and most bone phosphate. Between 3 inches and ¾ inch is the next grade, and all below ¾ inch is ground and sacked, being sold to small fertilizer companies or to the farmer for direct application. This system of preparation is based on the higher quality of the "lump" mentioned below (see "Chemistry"). It saves the small material, "spalls," etc., which might otherwise be lost, and making use of all the rock, is economical. No cleaning with log washers, etc., is now done in the field, although an experimental plant for this purpose is now in course of erection by Messrs. Cajot et Cie. Those mines not equipped with a mill simply dry the rock in kilns, break it to the required size with hammers, and either screen it or depend on the handling once or twice with ballast forks to cleanse it.

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[1] Report of Geol. Survey of Kentucky, chemical analyses A, part 3, 1890, p. 33 et seq.

Chemistry.—The Mount Pleasant phosphate contains no unusual ingredients, nor does it differ essentially in chemical composition from other high-grade rock phosphates of the world. It is, however, distinguished from the blue rock of Tennessee (the Devonian of the Swan Creek region) by its higher content of bone phosphate and iron and alumina and by containing no pyrite. The iron and alumina are present in about equal proportions, and seem to exist not as phosphates but as oxides or silicates. The fact that the larger pieces of rock, which show a comparatively small surface in comparison with their cubic contents, contain comparatively little iron and alumina, would seem to point to a derivation of these materials from the surface soil through suspension in the circulating waters.

The following analyses, made by the writer, were chiefly for commercial purposes, but they show distinctly the character of the rock:

Analyses of phosphate rock from Tennessee.

Constituents.	Mount Pleasant rock from mine, without preparation.	Lump rock from near bottom of stratum.	Average of several analyses of rock from one mine, ready for shipment	Same, from a different mine, ready for shipment.	Hard rock of Mount Pleasant, from property of Cajot et Cie.	Unaltered limestone.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	1.05	0.33	0.53	0.90	0.59	0.27
Phosphoric acid	34.69	37.61	36.89	37.11	37.22	22.59
Iron oxide	2.39	2.52	3.53	3.97	2.84	1.45
Alumina	3.36					
Carbonic acid	1.40					18.11
Lime carbonate	3.18			3.39		41.16
Sulphuric acid	1.68					
Sand and insoluble matter	4.05			3.97		1.78
Magnesia	.59					
Organic matter and water of combination	2.64					
Fluorine and undetermined	1.39					
Lime (CaO)	46.76					
Tribasic phosphate of lime (or bone phosphate) on dry basis	76.42	82.25	80.42	79.90	87.14	49.38

Companies.—The mining companies in the field, with their improvements, etc., are as follows:

Tennessee Phosphate Company mines at Ridley, 1 mile north of Mount Pleasant. Principal office, Louisville, Kentucky. Capacity, 60,000 tons per annum. Improvements consist of full mine equipment of tram tracks, cars, etc., hydraulic washer and screens, with elevating machinery, storage bins for 3,000 tons of rock, three large dry sheds, Gates crusher, engines to run machinery, elevators, etc.—in short, a fully equipped mill plant. The automatic car-loading device of this company, by means of which forty cars daily can be loaded by the labor of two men, is especially worth notice.

La Compagnie Générale des Phosphates de la Floride. Capital, 5,000,000 francs. Principal office, 83 Rue de Richelieu, Paris. Mines about 2 miles northeast of Mount Pleasant, at Solita, where work has just been begun, and where they have only tram tracks, etc., by way of improvements. Capacity will be about 30,000 tons.

J. H. Carpenter & Co. Mines about 2 miles northeast of Mount Pleasant, at Solita. Improvements consist of 3,000 feet of broad-gauge railway track from mines to main-line railway, dry sheds, shops, track scales, and trams to fully equip mine. Capacity, about 30,000 tons.

J. R. Bryan & Co. Principal offices at Mount Pleasant. Mines about 1 mile northeast of Mount Pleasant. Improvements consist of several hundred feet of railway track, dry sheds, etc.

Alphonse Cajot & Co. Principal offices at 42 Rue des Chaussées d'Antin, Paris. American offices at Mount Pleasant. Capital stock (paid up), 1,300,000 francs. Mines about 2 miles east of Mount Pleasant, and elsewhere. Improvements are in course of erection, and consist of washer, Delplace dryer, etc. This plant is in a measure experimental. Capacity is expected to be 40,000 to 50,000 tons per annum.

Elk Mineral Company are not miners, but handle ground rock. Output during 1898 probably about 10,000 tons.

Blue Grass Phosphate Company. Principal office, Nashville, Tennessee. Improvements consist of dry sheds, tram tracks, etc. Mines on eastern edge of town of Mount Pleasant.

J. W. Harder & Co. Offices at Mount Pleasant. Mines about 1 mile southeast of the village.

These are the principal producers. There are a few miners on a small scale who sell rock to buyers for factories or to larger operators. Farmers also occasionally mine a few tons when there is little work. As their rock is all sold "green," and must be dried, crushed, and screened, it can hardly be said to be very cheap, in spite of the low prices paid. The amount so produced is not large.

THE BLUE ROCK DISTRICT.

This has been well described by Dr. C. W. Hayes in this report for 1894, pages 610 et seq. It will therefore not be necessary to go over the ground again.

The effect of the discovery of the Mount Pleasant phosphates upon the industry in the Blue Rock district was most disastrous. Mount Pleasant furnished a higher grade of rock at less cost, and, above all, was supplied with transportation, so that it was not surprising that the district took the greater share of the business. The only wonder is that any blue rock continued to be sold; but it has such excellent quality for the manufacturer that miners so situated as to be able to compete with Mount Pleasant in cost free on board cars are still shipping rock, and the total shipments from the district during 1897 were by no means insignificant. Not all the shipments, however, were of blue rock (Devonian), as several hundred tons of rock from the geological horizon of the Mount Pleasant fields have been shipped from Centerville. It is hardly probable that the production of this field will be lessened for several years to come.

The producers operating are as follows:

Southwestern Phosphate Company. Principal office at Nashville. Mines on Swan Creek and Falls Branch, in Hickman County.

Robin Jones, receiver for the Swan Creek Phosphate Company. Office at Mount Pleasant, Tennessee. Mines on Haw Branch, etc., in Hickman County.

Duck River Phosphate Mining Company. Operating under lease from the receiver of the Duck River Phosphate Company. The mines are in Tottys Bend of Duck River, and are fully equipped with air drills, mine tracks, mill plant, etc.

J. H. Daniel & Co. Office at Twomey, Hickman County. Mines at Twomey and Centerville.

Tennessee Phosphate Company. Offices, etc., as given above.

PERRY COUNTY DISTRICT.

The geologic relations of this field have been clearly set forth by Dr. C. W. Hayes, in this report for 1894. Since that paper was written, further exploration of the breccia deposits has shown the existence of a considerable amount of high-grade rock, hardly to be distinguished in appearance, mode of occurrence, and composition from the hard rock of Florida. Such a result of prospecting was suggested by Dr. Hayes. While a good deal of prospecting has been done in this section, the ground has not yet been thoroughly explored with a view to ascertaining the exact extent of the deposits, and no shipments have been made, so that it is impossible to say anything about the cost of production. The rock is apparently of high grade, and could enter the foreign market with New Orleans as point of shipment provided sufficiently good rates were obtained for shipment down the Tennessee River, from which the deposits are distant about 4 miles. The Perry Phosphate Company, with offices at Ætna, Hickman County, controls the deposits. An average of six analyses made by the writer showed 1.67 per cent iron and alumina, 80.93 per cent bone phosphate, and 4.52 per cent lime carbonate.

OUTLOOK.

The outlook for miners in Tennessee during 1898 appears to be only fair. Only estimates of cost are obtainable, but the most reliable information puts cost, free on board at the mines, at $1.25 to $1.35. As the highest figures at which rock is now being sold in the field are $1.75 and the average probably $1.50, the margin of profit is very slight. Of late demand has increased and operators seem more hopeful, but whether this improvement is permanent remains to be seen. The rock has been well received abroad, and if freight rates continue to permit it this business may increase to considerable proportions. The fact that the manufacturers' mills will grind three times as much of this rock in a given time as of Florida hard rock of the same grade, should offset in good measure the slightly greater iron and alumina of the Tennessee product. The working qualities of the Tennessee rock are good, and it produces a high-grade acid phosphate when properly handled.

Production of phosphate rock in Tennessee for 1897.

[Long tons.]

Month.	Centerville district.	Mount Pleasant district.	Total.
January	1,509	6,905	8,414
February	1,429	6,845	8,274
March	1,888	6,537	8,425
April	1,771	8,242	10,013
May	1,571	9,299	10,870
June	1,564	5,013	6,577
July	1,861	8,833	10,694
August	2,729	7,123	9,852
September	2,450	9,729	12,179
October	2,376	10,488	12,864
November	2,121	8,964	11,085
December	1,750	10,232	11,982
Year	23,019	98,210	121,229

Phosphate shipments from Maury County, Tennessee, in 1896.

Month.	Long tons.
July	350
August	2,582
September	2,566
October	2,240
November	4,809
December	6,831
Total	19,378

Shipments of phosphate rock from Tennessee during 1897.

Month.	Mount Pleasant district.	Blue Rock district.	Total.
	Long tons.	*Long tons.*	*Long tons.*
January	7,185	1,110	8,295
February	7,583	1,031	8,614
March	6,059	1,491	7,550
April	8,527	1,373	9,900
May	7,835	1,173	9,008
June	7,352	1,112	8,464
July	7,869	1,463	9,332
August	7,197	2,331	9,528
September	9,858	2,052	11,910
October	10,512	1,978	12,490
November	10,516	1,753	12,269
December [a]	9,330	1,500	10,830
Total	99,823	18,367	118,190

[a] Estimated.

The value of the 99,823 tons shipped from Mount Pleasant district was $149,234, and the Blue Rock district shipments of 18,367 tons amounted to $33,979, making a total value of $183,213 for the 118,190 long tons shipped from Maury County during 1897.

The following table shows the distribution of the shipments for consumption:

Shipments of phosphate rock from Tennessee during 1897 to domestic or foreign points.

Shipped to—	Mount Pleasant district.	Blue Rock district.	Total.
	Long tons.	*Long tons.*	*Long tons.*
Domestic points	73,841	18,367	92,208
Foreign ports	25,982		25,982
Total	99,823	18,367	118,190

IMPORTS.

The following table shows the imports of fertilizers of all kinds into the United States from 1868 to 1897:

Fertilizers imported and entered for consumption in the United States, 1868 to 1897.

Year ending—	Guano.		Crude phosphates and other substances used for fertilizing purposes.		Total value.
	Quantity.	Value.	Quantity.	Value.	
June 30—	*Long tons.*		*Long tons.*		
1868	99, 668	$1, 336, 761	....	$88. 864	$1, 425, 625
1869	13, 480	217, 004	....	61, 529	278, 533
1870	47, 747	1, 414, 872	....	90, 817	1, 505, 689
1871	94, 344	3, 313, 914	....	105, 703	3, 419, 617
1872	15, 279	423, 322	....	83, 342	506, 664
1873	6, 755	167, 711	....	218, 110	385, 821
1874	10, 767	261, 085	....	243, 467	504, 552
1875	23, 925	539, 808	....	212, 118	751, 926
1876	19, 384	710, 135	....	164, 849	874, 984
1877	25, 580	873, 459	....	195, 875	1, 069, 334
1878	23, 122	849, 607	....	285, 089	1, 134, 696
1879	17, 704	634, 546	....	223, 283	857, 829
1880	8, 619	108, 733	....	317, 068	425, 801
1881	23, 452	399, 552	....	918, 835	1, 318, 387
1882	46, 699	854, 463	133, 956	1, 437, 442	2, 291, 905
1883	25, 187	537, 080	96, 586	798, 116	1, 335, 196
1884	28, 090	588, 033	35, 119	406, 233	994, 266
1885	20, 934	393, 039	40, 068	611, 284	1, 004, 323
Dec. 31—					
1886	13, 520	306, 584	82, 608	1, 179, 724	1, 486, 308
1887	10, 195	252, 265	53, 100	644, 301	896, 566
1888	7, 381	125, 112	36, 405	329, 013	454, 125
1889	15, 991	313, 956	35, 661	403, 205	717, 161
1890	4, 642	59, 580	31, 191	252, 787	312, 367
1891	11, 937	199, 044	29, 743	214, 671	413, 715
1892	3, 073	46, 014	92, 476	666, 061	712, 075
1893	5, 856	97, 889	106, 549	718, 871	816, 760
1894	5, 757	105, 991	126, 820	904, 247	1, 010, 238
1895	4, 270	51, 642	80, 088	450, 379	502, 021
1896	6, 532	79, 815	113, 955	639, 858	719, 673
1897	4, 930	55, 715	200, 598	970, 836	1, 026, 551

SULPHUR AND PYRITES.

By EDWARD W. PARKER.

SULPHUR.

PRODUCTION.

Compared with the domestic consumption of sulphur, the production in this country continues to be of small proportions. The United States consumes annually about 135,000 short tons of sulphur, in addition to the iron pyrites, domestic and imported, used in the manufacture of sulphuric acid. The largest production of sulphur in this country, so far as records are obtainable, was in 1896, when the output amounted to 5,260 short tons, valued at $87,200. The average yearly production for the sixteen years previous to 1896 was 1,372 tons. The largest production in this period was in 1887, when 3,000 tons were mined in Utah by the Dickert and Myers Sulphur Company, now out of existence. In two years, 1888 and 1890, no production was reported. During 1897 the production was 2,275 short tons, only 43 per cent of the amount produced in 1896, but an increase of 68 per cent over the average yearly production in the sixteen years preceding 1896. The increased output in 1896 was due to the operations of the Frasch process in Louisiana. This process consists in melting the sulphur by superheated water, and pumping or forcing it to the surface. The principles of the "air lift" pump have recently been applied to this enterprise. About 80 per cent of the product in 1896 was from the Louisiana deposit. These works were shut down the greater part of 1897, and the production there was only about one-fourth of what it was the preceding year. The mines of Black Rock, Utah, produced about the same amount as in 1896, and a little more than one-half the total product in 1897. The Utah deposits are extensive, and yield an excellent quality of sulphur, but owing to the expense attaching to railroad transportation the product has been restricted to a comparatively local market. At the time of writing this report (May, 1898) the prices of sulphur have advanced to unusually high figures—more than one and one-half times the average for 1897. The advance has been due to the existence of hostilities between the United States and Spain, sulphur being classed as contraband of war, and the United States being dependent chiefly upon foreign sources for her supply. It is possible that this condition of affairs, particularly the incentive of remunerative returns consequent upon the advance in prices, will not only stimulate production in the two regions mentioned, but attract attention to and cause the early development of other properties.

Owners of the sulphur deposits in western Texas have been actively pushing the work of thoroughly prospecting the locality, but the information furnished to the Survey as to the extent and economic value of the sulphur has been given with the understanding that it would not be published until all formalities necessary to perfection of title, etc., have been complied with.

Sulphur deposits in eastern Texas, in the vicinity of the city of Beaumont, have attracted attention, and preparations are being made to develop them. A plant for mining the sulphur and for making sulphuric acid is to be constructed about 4 miles from Beaumont, on the Sabine and East Texas railroad. With the United States at present depending upon the island of Sicily for five-sixths of her sulphur supply, and upon foreign sources generally for 98 per cent of her total consumption, and with this article declared contraband of war, it would seem that the present is the golden opportunity for the development of American sulphur deposits.

The following table shows the product of sulphur in the United States since 1880:

Sulphur product of the United States since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	600	$21,000	1889	450	$7,850
1881	600	21,000	1890	....	....
1882	600	21,000	1891	1,200	39,600
1883	1,000	27,000	1892	2,688	80,640
1884	500	12,000	1893	1,200	42,000
1885	715	17,875	1894	500	20,000
1886	2,500	75,000	1895	1,800	42,000
1887	3,000	100,000	1896	5,260	87,200
1888	....	....	1897	2,275	45,590

DOMESTIC CONSUMPTION.

In discussing the production, importations, and consumption of sulphur, the use of iron pyrites in the manufacture of sulphuric acid must be considered. During the past decade iron pyrites has become a formidable rival to sulphur, but it is for the past seven years only that reliable statistics are available. Previous to 1884 pyrites was included with other sulphur ores in the reports of imports published by the Treasury Department. From 1887 to 1891 iron pyrites was included with other iron ores. From 1884 to 1887 and since 1891 iron pyrites containing not more than 3.5 per cent of copper has been reported separately. In 1887 the pyrites imported into the United States amounted to only 16,578 long tons, and the domestic product was only 52,000 long tons. Four years later (1891), when the imports were next reported, they amounted to 100,648 long tons and the domestic product more than doubled. Assuming that the pyrites, imported and domestic, contained an average of 45 per cent of sulphur, it is seen that in 1891 93,233 long tons of sulphur was displaced by pyrites, of which 45,292 long tons was from imported ores. In the same year it is shown that the imports of crude sulphur amounted to 116,971 long tons, against 162,674 long tons in 1890, a decrease of 45,703 long tons, substantially the same as the amount of sulphur contained in imported pyrites. The imports of sulphur decreased again about 16,000 long tons in 1892, while the sulphur contents of imported pyrites increased about 23,000 long tons. In 1893 there was an increase of 4,600 long tons in the imports of sulphur, an increase of over 19,000 long tons in the sulphur contents of imported pyrites, and a decrease of over 15,000 long tons in the sulphur contents of domestic pyrites. Previous to this, since 1887, there had been a constant increase in the production of iron pyrites. In 1894 is seen an increase of nearly 20,000 long tons in the imports of sulphur, and of 13,573 long tons of sulphur in domestic pyrites, and a decrease of 13,119 long tons in sulphur contained in foreign pyrites. During 1895 the imports of sulphur showed a decrease of 4,000 tons. The production of domestic pyrites also decreased, the sulphur contents being 3,000 tons less than in 1894, while the sulphur contents of imported pyrites in 1895 were 11,000 tons in excess of the preceding year. In 1896 there was an increase all along the line, the total sulphur consumption showing a gain of 32,500 tons over the preceding year. Another large increase in the total consumption is indicated in the returns for 1897. The aggregate was 35,000 tons more than in 1896. This increase was entirely in the use of iron pyrites. The production of domestic pyrites increased nearly 28,000 long tons, the sulphur contents showing an increase of about 12,500 tons. The sulphur contents of imported pyrites, as estimated, increased 26,700 tons, while sulphur, imported and domestic, shows a decrease of about 4,200 tons. In the six years from 1891 to 1897 the consumption of sulphur in the United

States has grown from 211,275 to 319,830 long tons, an increase of 108,555 tons, or a little more than 50 per cent. Comparatively, the domestic product of sulphur has been so small that it has been disregarded in the discussion, but is shown in the following table:

Estimated consumption of sulphur in the United States from 1891 to 1897.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Sulphur:							
Domestic	1,071	2,400	1,071	446	1,607	4,696	2,031
Imported (*a*)....	116,971	100,938	105,539	125,241	121,286	138,168	136,563
Sulphur contents of pyrites: (*b*)							
Domestic	47,941	49,405	34,100	47,673	44,697	51,968	64,440
Imported	45,292	68,561	87,715	74,596	85,796	90,076	116,796
Total domestic consumption.........	211,275	221,304	228,425	247,956	253,386	284,908	319,830

a Crude sulphur only; does not include flowers of sulphur, refined sulphur, or sulphur lac.
b Based on average sulphur contents of 45 per cent.

In the foregoing table the domestic production of sulphur has been reduced from short tons to long tons for the sake of uniformity.

REVIEW OF THE INDUSTRY.

The bulk of the sulphur product of the world is obtained from the island of Sicily, off the southern coast of Italy. Conditions, therefore, which affect the sulphur industry of Sicily influence the sulphur industry of the world. In 1896 the combination or "trust" known as the Anglo-Sicilian Sulphur Company, Limited, of London, England, began its operations. Under its contracts it secures control of 70 per cent of the entire output of Sicily, guaranteeing the producers a fixed price of $15.94 per ton, with an advance of 1 cent per ton on every 3 per cent reduction of output ordered, this rate being based on an annual production of 340,000 tons. The export duty previously imposed was practically abolished by the Italian Government, an exaction of only 1 lire per ton being made. Prices for Sicilian sulphur had been greatly demoralized for two or three years prior to the syndicate taking hold. In 1895 and the early part of 1896 they were the lowest ever known. Best unmixed seconds sold in New York in March, 1896, at $15 per ton. After this they advanced steadily, under the manipulations of the syndicate, until $25 per ton was reached in October. This high figure, however, could not be maintained, notwithstanding the strength of the syndicate and the increased consumption in the United States. The price declined until a point about midway between the above extremes was reached in the earlier months of 1897.

The Anglo-Sicilian Sulphur Company controls not only the greater part of the sulphur product of Sicily, but also the sulphur recovered in England from alkali waste. The first annual statement issued by the company ends with July 31, 1897. It shows that the company received from the producers 267,795 tons of sulphur during the year. This would have been increased to about 300,000 tons were it not for the fact that some sulphur (about 50,000 tons) remained to be delivered by the producers upon contracts made prior to the one entered into with the Anglo-Sicilian Company. The financial statement of the company shows that the gross profits for the year amounted to about $340,000. From this were deducted the expenses incurred in Sicily and London, about $95,000, making net profits amounting to about $245,000. From this $32,000 was written off for good will and preliminary expenses, and the balance, after placing about $45,000 to the capital guaranty fund and the general reserve, was distributed as dividends to the shareholders.

That the operations of the syndicate have encouraged the use of pyrites in acid making is evinced by the increased production and importation of this sulphur ore. The production of iron pyrites has increased from 99,549 long tons in 1895 to 143,201 tons in 1897. Imported pyrites increased from 190,435 tons in 1895 to 259,546 tons in 1897. The two show a total increase of about 113,000 long tons, or nearly 40 per cent. There was a slight decrease in the imports of sulphur in 1897. It is the opinion of many familiar with the sulphur industry that the minimum limit set by the company as the basis of its contracts is in excess of the consumptive demand, and that accumulations of sulphur at shipping points are bound to occur. Increasing consumption of pyrites for acid making will without doubt cause a still wider gulf between the supply of and the demand for Sicilian sulphur. Indications at present are that under ordinary circumstances the syndicate will have to order a restricted production, involving an increased cost to it, or obtain concessions from its original contracts with the producers. Aside from the error in making the minimum limit and the increasing consumption of pyrites, the syndicate is somewhat at the mercy of independent miners, who are able to sell sulphur at prices below those at which the syndicate can afford to sell under its contracts.

PRICES OF SICILIAN SULPHUR.

Mr. Alfred S. Malcomson has furnished the Survey with the following statement of the prices of Silician sulphur, best unmixed seconds, ex steamer New York, for each month during 1896 and 1897 and up to June, 1898. The wide variation between the extremes of prices in April and May, 1898, was due to the war with Spain. In each case the lower figure was for sulphur sold previously for April and May delivery. The higher prices were for spot sulphur after hostilities began and before the syndicate could make arrangements for shipping.

Spot prices for Sicilian sulphur, per long ton, ex steamer at New York.

Date.	1896.	1897.	1898.
January	$15.50	$20.00 @ $20.50	$20.50
February	15.50	19.75	20.50
March	15.00	20.00	21.50
April	15.50	19.25 @ 19.50	$21.50 @ 35.00
May	$15.50 @ 16.00	19.25 @ 19.50	21.75 @ 32.00
June	19.00	19.25	24.00
July	19.50	19.75	....
August	20.00 @ 21.00	20.00	....
September	22.50 @ 23.00	21.00	....
October	24.00 @ 25.00	21.00	....
November	22.00	21.00	....
December	21.00	20.75	....

IMPORTS.

Sulphur imported and entered for consumption in the United States, 1867 to 1897.

Year ended—	Crude.		Flowers of sulphur.		Refined.		All other.(*a*)		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		*Long tons.*		*Long tons.*		
June 30, 1867	24,544	$620,373	110	$5,509	251	$10,915	....	....	$636,797
1868	18,151	446,547	16	948	65	2,721	....	....	450,216
1869	23,590	678,642	97	4,576	645	27,149	....	....	710,367
1870	27,380	819,408	76	3,927	157	6,528	....	$1,269	831,132
1871	36,131	1,212,448	66	3,514	92	4,328	....	754	1,221,044
1872	25,380	764,798	36	1,822	57	2,492	....	....	769,112
1873	45,533	1,301,000	55	2,924	36	1,497	....	....	1,305,421
1874	40,990	1,260,491	51	2,694	57	2,403	....	....	1,265,588
1875	39,683	1,259,472	18	891	....	....	....	....	1,260,363
1876	46,435	1,475,250	41	2,114	44	1,927	....	....	1,479,291
1877	42,963	1,242,888	116	5,873	1,171	36,962	....	....	1,285,723
1878	48,102	1,179,769	159	7,628	150	5,935	....	....	1,193,332
1879	70,370	1,575,533	138	6,509	69	2,392	....	....	1,584,434
1880	87,837	2,024,121	124	5,516	158	5,262	....	....	2,034,899
1881	105,097	2,713,485	98	4,226	71	2,555	....	....	2,720,266
1882	97,504	2,627,402	159	6,926	59	2,196	....	....	2,636,524
1883	94,540	2,288,946	79	3,262	115	4,487	....	....	2,296,695
1884	105,112	2,242,697	178	7,869	126	4,765	....	....	2,255,331
1885	96,839	1,941,943	121	5,351	114	4,060	....	....	1,951,354
1886	117,538	2,237,989	213	8,739	116	3,877	....	....	2,250,605
1887	96,882	1,688,360	279	9,980	84	2,383	....	....	1,700,723
Dec. 31, 1888	98,252	1,581,583	128	4,202	27	734	....	....	1,586,519
1889	135,933	2,068,208	15	1,954	10	290	....	....	2,070,461
1890	162,674	2,762,953	12	1,718	103	3,060	....	....	2,767,731
1891	116,971	2,675,192	206	6,782	10	1,997	....	....	2,683,971
1892	100,938	2,189,481	158	5,439	26	4,106	....	....	2,199,026
1893	105,539	1,903,198	241	5,746	43	1,017	....	....	1,909,961
1894	125,241	1,703,265	173	4,145	45	1,207	....	....	1,708,617
1895	121,286	1,546,481	581	12,888	229	4,379	....	50,006	1,613,754
1896	138,168	1,967,454	665	13,266	447	8,226	....	183,683	2,172,569
1897	136,563	2,395,436	....	....	....	....	5,342	58,637	2,454,073

a Includes sulphur lac and other grades not otherwise provided for, but not pyrites.

Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1897.

Countries whence exported and customs districts through which imported.	1876.		1877.		1878.		1879.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
Dutch West Indies and Guiana	1,515	$15,427						
England	30	1,211	425	$14,631	(?)	$16	2	$335
Scotland	24	910	472	13,231	160	3,961	806	19,287
Gibraltar			290	7,789				
Quebec, Ontario, Manitoba, etc					12	264		
Italy	46,941	1,439,839	41,819	1,194,000	47,494	1,161,367	64,420	1,453,138
Japan	456	16,291	437	13,137	256	7,548	224	4,528
Portugal							467	10,410
Total	48,966	1,473,678	43,443	1,242,788	47,922	1,173,156	65,919	1,487,698
DISTRICTS.								
Baltimore, Md	5,157	157,828	3,882	105,175	5,455	138,202	6,969	157,243
Barnstable, Mass							600	13,780
Boston and Charlestown, Mass	5,031	154,883	3,931	101,215	5,795	131,945	7,841	173,506
Charleston, S. C					526	12,267	605	13,812
Delaware, Del	450	13,500					890	21,907
Huron, Mich					12	264		
Newark, N. J			1,071	31,802	462	13,240	443	10,175
New Orleans, La	172	5,705	150	4,750			100	2,087
New York, N. Y	24,524	721,092	21,867	654,997	28,240	690,989	36,543	827,193
Philadelphia, Pa	12,549	385,671	9,216	256,224	6,657	167,222	11,704	263,467
Providence, R. I	600	18,232	1,739	45,487	519	11,479		
San Francisco, Cal	483	17,367	862	27,768	256	7,548	224	4,528
Savannah, Ga			725	15,370				
Total	48,966	1,473,678	43,443	1,242,788	47,922	1,173,156	65,910	1,487,698

Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1897—Continued.

Countries whence exported and customs districts through which imported.	1880.		1881.		1882.		1883.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
England	1	$22	......	......	......	......	13	$379
Scotland	1,664	36,444	1,668	$43,311	755	$20,294	3	88
France	988	23,580	......	......	526	13,770	34	858
French West Indies	......	......	......	......	2	8	......	......
Greece	......	......	......	......	500	13,927	......	......
Italy	80,301	1,862,712	102,771	2,645,293	92,944	2,504,862	92,861	2,248,870
Japan	282	4,744	691	16,253	2,980	66,356	1,038	23,714
Santo Domingo	......	......	......	......	240	7,875	......	......
Spain	......	......	308	8,637	......	......	500	12,856
Spanish possessions in Africa and adjacent islands	......	......	......	......	9	310	87	2,030
Total	83,236	1,927,502	105,438	2,713,494	97,956	2,627,402	94,536	2,288,795
DISTRICTS.								
Baltimore, Md	13,827	313,342	16,477	430,917	13,781	364,384	11,977	286,438
Beaufort, S. C	......	......	......	......	540	13,889	......	......
Boston and Charlestown, Mass	8,207	183,486	8,860	226,801	7,467	194,317	7,756	173,569
Charleston, S. C	1,061	25,398	3,065	78,741	6,025	161,281	4,051	106,235
Middletown, Conn	......	......	......	......	9	310	......	......
New Orleans, La	280	7,121	100	2,646	220	6,516	428	10,378
New York, N. Y	46,657	1,083,784	57,608	1,463,082	46,531	1,260,222	45,885	1,110,313
Philadelphia, Pa	10,679	254,892	17,987	477,547	14,839	408,611	22,772	549,095
Providence, R. I	1,255	31,155	650	17,507	1,244	33,036	535	13,830
Richmond, Va	......	......	......	......	660	17,760	......	......
San Francisco, Cal	1,270	28,324	691	16,253	6,054	151,234	1,072	24,572
Savannah, Ga	......	......	......	......	586	15,842	560	14,365
Total	83,236	1,927,502	105,438	2,713,494	97,956	2,627,402	94,536	2,288,795

***Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1897*—Continued.**

Countries whence exported and customs districts through which imported.	1884. (*a*)		1885.		1886.		1887.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
Belgium	......	......	190	$4,766	60	$1,718	......	......
Danish West Indies	......	......	......	......	......	......	861	$5,250
England	......	......	606	15,084	81	2,535	162	4,437
France	......	......	......	......	......	......	290	6,951
Quebec, Ontario, Manitoba, and the Northwest Territory	......	......	......	......	......	9	......	......
Italy	......	......	94,370	1,894,858	112,283	2,166,565	89,924	1,588,146
Japan	......	......	1,541	25,683	4,972	66,505	6,146	83,576
Spain	......	......	134	1,552	......	......	......	......
Total	105,143	$2,242,678	96,841	1,941,943	117,396	2,237,332	97,383	1,688,360
DISTRICTS.								
Baltimore, Md	15,037	303,226	14,505	285,006	19,807	364,958	12,547	225,669
Barnstable, Mass	650	16,163	480	11,040	1,617	35,385	1,152	22,816
Beaufort, S. C	600	13,259	610	12,847	......	......	......	......
Boston and Charlestown, Mass	5,294	112,152	5,125	99,712	3,681	69,898	4,850	85,575
Champlain, N. Y	......	......	......	......	......	9	......	......
Charleston, S. C	6,125	132,570	8,525	169,564	13,350	265,265	12,420	220,598
New Orleans, La	......	......	102	2,282	250	5,102	......	......
New York, N. Y	52,478	1,135,725	45,537	909,128	58,758	1,115,519	46,711	792,114
Philadelphia, Pa	18,786	401,568	18,696	381,010	15,568	300,749	15,267	269,216
Providence, R. I	651	15,517	1,840	37,422	1,265	25,930	600	11,291
San Francisco, Cal	5,522	112,598	1,421	33,937	3,600	54,517	3,176	50,521
All other customs districts	......	......	......	......	......	......	660	10,560
Total	105,143	2,242,678	96,841	1,941,943	117,396	2,237,332	97,383	1,688,360

a Sources not reported.

Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1897—Continued.

Countries whence exported and customs districts through which imported.	1888.		1889.		1890.		1891.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
Belgium	83	$1,993	180	$4,086	182	$3,995	267	$6,576
Danish West Indies					550	9,076		
England	310	7,200	305	8,337	4,898	101,100	5,613	127,976
Scotland					20	427		
Italy	92,528	1,499,720	123,260	1,935,368	115,240	1,800,585	101,660	2,140,516
Japan	6,332	72,729	6,441	77,853	21,031	221,316	12,763	168,073
Other countries							501	8,372
Total	99,253	1,581,582	130,191	2,025,644	141,921	2,136,559	120,804	2,451,513
DISTRICTS.								
Baltimore, Md	11,989	182,769	15,791	234,693	21,198	322,018	9,339	247,324
Beaufort, S. C	500	9,000	600	9,213			1,300	26,951
Boston and Charlestown, Mass	3,760	62,298	6,446	104,257	7,410	135,044	6,381	136,402
Charleston, S. C	12,005	199,048	23,377	364,859	15,752	255,106	28,281	557,384
Mobile, Ala							750	14,863
New Orleans, La	200	3,845			200	3,397	1,300	30,474
New York, N. Y	50,486	816,286	60,922	959,872	66,359	983,754	44,027	910,075
Pensacola, Fla							1,399	23,206
Philadelphia, Pa	10,519	173,699	13,288	202,357	13,919	210,576	10,842	216,763
Providence, R. I	1,310	21,012	570	8,581	1,240	19,160		
San Francisco, Cal	6,352	78,732	4,539	57,925	8,223	87,391	8,819	115,637
Savannah, Ga			2,345	44,244	5,560	86,826	5,245	99,717
Willamette, Oreg							288	11,852
Wilmington, N. C	1,532	25,893	1,753	28,443	2,040	32,800	2,832	60,843
All other customs districts	600	9,000	560	11,200	20	287	1	22
Total	99,253	1,581,582	130,191	2,025,644	141,921	2,136,559	120,804	2,451,513

Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1897—Continued.

Countries whence exported and customs districts through which imported.	1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*	
England	6,522	$162,616	8,777	$196,914	12,435	$228,300
Scotland			1,452	27,288		
France	1	23				
Quebec, Ontario, etc	1	49	8	269		
Italy	90,668	2,147,942	103,146	958,303	68,854	1,031,690
Spain					899	15,343
Japan	12,227	213,776	8.307	133,455	4,777	62,567
Total	109,419	2,524,406	121,690	2,305,464	86,965	1,337,900
DISTRICTS.						
Baltimore, Md	9,981	263,293	13,759	271,949	9,854	132,272
Beaufort, S. C						
Boston and Charlestown, Mass.	9,086	221,033	11,001	224,624	12,649	227,976
Charleston, S. C	14,651	364,593	10,885	209,246	10,560	163,358
Mobile, Ala					774	12,740
New Orleans, La	2,118	47,165	2,441	43,970	2,407	34,184
New York, N. Y	52,647	1,191,169	57,474	1,085,289	35,319	548,742
Norfolk and Portsmouth, Va						
Philadelphia, Pa	9,380	211,570	12,625	241,293	5,149	73,980
Portland, Me	2,000	42,400				
Providence, R. I					700	9,063
San Francisco, Cal	7,256	127,797	7,766	125,507	4,424	59,790
Savannah, Ga			4.650	86,562	2,712	42,439
Willamette, Oreg	398	6,860	541	7,948	559	6,647
Wilmington, N. C	1,900	48,388	540	8,807	1,858	26,709
Vermont			8	269		
All other customs districts	2	72				
Total	109,419	2,524,406	121,690	2,305,464	86,965	1.337,900

Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1897—Continued.

Countries whence exported and customs districts through which imported.	1895.		1896.		1897.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Long tons.		*Long tons.*		*Long tons.*	
COUNTRIES.						
England	17,332	$272,307	15,640	$248,498	10,298	$194,992
Italy	96,162	1,296,989	125,850	1,586,551	108,908	1,821,056
Japan	14,241	130,988	8,997	95,244	9,446	140,426
Other countries	....	....	....	....	1,481	27,133
Total	127,735	1,700,784	150,487	1,930,293	130,133	2,183,607
DISTRICTS.						
Baltimore, Md	10,706	150,129	13,759	169,666	10,139	161,524
Beaufort, S. C	800	11,669	660	8,250	....	....
Boston and Charlestown, Mass	19,683	301,749	19,564	304,374	14,088	259,559
Charleston, S. C	11,576	143,915	9,730	118,885	6,370	109,186
Mobile, Ala	880	13,027	....	....	....	....
New Orleans, La	1,260	17,179	2,139	28,711	3,050	53,041
New York, N. Y	55,484	702,998	74,281	914,504	61,151	1,035,786
Norfolk and Portsmouth, Va	700	8,368	2,400	31,970	1,153	17,650
Philadelphia, Pa	8,216	110,841	9,085	122,195	6,726	111,725
Portland, Me	....	....	1,600	21,435	5,400	94,279
Providence, R. I	1,604	21,779	580	7,276	....	....
Puget Sound, Wash	....	....	458	5,710	32	1,275
San Francisco, Cal	6,356	64,758	6,370	66,934	9,973	134,565
Savannah, Ga	8,965	135,816	7,764	102,905	7,295	129,747
Willamette, Oreg	885	9,423	47	720	2,696	42,020
Wilmington, N. C	620	9,133	2,050	26,758	2,060	33,250
Total	127,735	1,700,784	150,487	1,930,293	130,133	2,183,607

EXPORTS OF SICILIAN SULPHUR.

The figures in the following tables, showing exports of sulphur from Sicily, the countries to which exported, and the ports through which the imports into the United States were received, have been furnished by Mr. A. S. Malcomson, of New York.

Total exports of sulphur from Sicily since 1883.

Country.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United States	96,629	94,929	99,378	98,590	89,419	128,265	109,008
France	63,602	65,098	58,264	54,280	56,222	52,083	67,340
Italy	66,810	56,292	49,415	48,658	48,997	47,664	43,523
United Kingdom	41,788	40,760	33,402	30,236	30,007	35,634	39,203
Greece	10,494	7,033	13,664	19,697	18,370	5,809	10,158
Portugal	15,298	11,018	17,760	30,943	16,587	15,851	16,799
Russia	10,413	12,831	13,420	10,570	13,441	22,043	17,678
Germany	7,232	6,622	6,103	8,689	9,700	12,402	15,401
Austria	4,915	6,037	5,965	5,800	6,702	8,942	8,984
Turkey	3,043	1,285	3,077	4,598	6,238	1,457	2,231
Spain	5,242	3,920	2,243	5,890	5,873	3,433	6.586
Belgium	7,660	6,793	9,516	6,580	5,318	6,951	7,752
Holland	1,256	696	1,237	2,999	1,747	2,793	2,424
Sweden	1,010	744	328	1,916	1,169	3,004	3,899
South America	....	....	....	....	710	95	23
Australia	....	....	....	....	600	885	....
Denmark	....	....	810	....	202	464	443
Total	335,392	314,058	314,582	329,446	311,302	347,775	351,451

Total exports of sulphur from Sicily since 1883—Continued.

Country.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United States	106,656	97,520	84,450	83,901	105,773	99,227	124,923	118,137
France	71,790	56,168	73,176	89,736	56,932	69,696	76,739	84,895
Italy	40,231	42,212	38,711	54,486	49,895	49,349	54,009	73,052
United Kingdom	26,213	23,408	24,853	27,453	22,165	24,043	21,913	24,520
Greece and Turkey	18,103	11,414	*a*14,845	*a*13,840	*a*16,870	*a*16,195	*a*18,556	13,860
Portugal	16,695	11,439	13,490	14,545	8,670	14,562	12,001	7,054
Russia	17,158	11,930	14,178	19,730	17,977	17,962	18,752	17,532
Germany	15,703	10,629	14,326	16,259	16,437	15,472	15,680	19,721
Austria	8,746	10,575	9,096	10,169	11,494	12,170	13,799	15,993
Turkey	4,231	3,000	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
Spain	5,679	5,845	7,382	3,499	3,445	5,753	5,910	4,039
Belgium	7,279	5,089	5,133	4,358	5,644	6,410	7,527	9,253
Holland	....	....	2,183	2,957	2,365	3,335	3,834	3,599
Sweden	3,314	2,252	4,561	6,579	7,887	5,730	14,540	11,226
Australia	....	....	1,200	....	....	....	....	....
Denmark	400	300	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Other countries	2,565	3,542	3,152	1,680	3,376	7,732	8,562	7,651
Total	344,763	293,323	309,536	349,192	328,930	347,636	396,745	410,538

a Exports to Greece and Turkey combined after 1892. *b* Included in exports to Sweden.

PORTS IN THE UNITED STATES RECEIVING SICILIAN SULPHUR.

The ports in the United States to which such shipments were made, together with the amount shipped to each since 1883, and the quality of the shipments since 1886, are shown in the following tables:

Ports in the United States receiving Sicilian sulphur, and the amount received by each.

Port.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	41,238	46,460	50,814	49,952	45,979	60,706	55,939
Charleston	5,425	7,706	12,416	10,556	14,324	22,496	12,399
Philadelphia	23,123	19,234	12,153	15,662	11,764	11,793	14,334
Baltimore	16,175	13,986	16,435	15,680	10,306	17,330	15,316
Boston	5,864	4,723	4,200	3,800	3,300	6,300	4,950
Wilmington, N. C	....	....	....	....	1,020	2,355	2,040
Savannah	....	....	....	....	....	3,545	3,210
Port Royal	600	610	680	660	1,000	600	....
Providence	650	1,140	1,370	1,180	630	1.250	590
Sundries	670	....	....	....	600	480	....
San Francisco	1,884	500	....	....	296	....	....
New Orleans	350	100	250	....	200	250	200
Woods Hole	650	470	1,060	1,100	....	1,160	....
Total	96,629	94,929	99,378	98,590	89,419	128,265	109,008

Ports in the United States receiving Sicilian sulphur, etc.—Continued.

Port.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	37,390	49,023	49,090	43,896	46,875	55,863	68,353	70,474
Charleston	27,563	21,646	4,510	13,525	15,296	9,150	7,700	5,130
Philadelphia	11,094	6,856	10,400	8,160	5,400	8,350	6,000	5,409
Baltimore	16,700	11,365	12,355	9,950	15,300	9,720	14,150	13,831
Boston	2,500	1,950	3,325	500	4,317	4,950	5,300	8,220
Wilmington, N. C	1,309	2,600	....	1,140	1,890	650	2,660	1,550
Savannah	5,920	1,550	1,170	5,330	9,795	4,584	9,395	4,700
Pensacola	1,390	....	....	....	....	....	....	....
Port Royal	600	700	....	....	800	....	660	....
Providence	650	....	....	....	1,500	1,380	....	....
San Francisco	....	....	....	....	....	....	3,125	....
New Orleans	800	1,200	2,000	1,900	2,400	1,700	2,100	3,340
Mobile	740	....	....	....	800	880	....	....
Delaware Breakwater	....	630	....	....	....	....	....	....
Portland, Me	....	....	2,000	....	....	1,300	2,550	4,343
Norfolk	....	....	....	....	1,400	700	2,930	1,140
Total	106,656	97,520	84,850	83,901	105,773	99,227	124,923	118,137

Quality of Sicilian sulphur received at the different ports of the United States since 1886.

Port.	1886.		1887.		1888.		1889.	
	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	36,352	13,600	29,919	16,060	35,573	25,133	32,983	22,956
Charleston	7,506	3,050	8,875	5,449	15,485	7,011	6,325	6,074
Philadelphia	4,660	11,002	2,127	9,637	3,050	8,743	2,000	12,334
Baltimore	7,325	8,355	4,463	5,843	11,380	5,950	7,656	7,660
Boston	600	3,200	200	3,100	700	5,600	750	4,200
Savannah	......	......	......	......	2,130	1,415	2,790	1,450
Wilmington, N. C	......	......	1,020	......	2,355	......	2,040	......
Other ports	1,180	1,760	106	2,620	1,500	2,240	200	590
Total	57,623	40,967	46,710	42,709	72,173	56,092	53,744	55,264

Quality of Sicilian sulphur received at the different ports, etc.—Continued.

Port.	1890.		1891.		1892.		1893.	
	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York..........	20,801	16,589	29,358	19,665	34,390	14,700	29,146	14,250
Charleston.........	20,873	6.690	17,196	4,450	4,010	500	11,665	1,860
Philadelphia.......	1,000	10,094	450	6,406	3,600	6,800	1,900	6,260
Baltimore..........	5,930	10,770	4,510	6,855	900	11,455	2,050	7,900
Boston..............	200	2,300	1,300	650	1,825	1,500	500	....
Savannah...........	2,750	3,170	850	700	600	570	3,450	1,880
Wilmington, N. C...	1,309	....	1,900	700	....	....	....	1,140
New Orleans.......	....	....	....	....	....	....	1,900	....
Other ports........	1,540	2,640	1,200	1,330	4,000	....	....	....
Total........	54,403	52,253	56,764	40,756	49,325	35,525	50,611	33,290

Port.	1894.		1895.		1896.		1897.	
	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York..........	33,150	13,725	35,888	19,975	50,557	17,796	57,174	13,300
Charleston.........	3,273	12,023	700	8,450	2,330	5,370	1,500	3,630
Philadelphia.......	350	5,050	1,200	7,150	500	5,500	199	5,210
Baltimore..........	600	14,700	1,100	8,620	3,650	10,500	3,798	10,033
Boston..............	1,017	3,300	2,350	2,600	4,600	700	7,220	1,000
Savannah...........	5,695	4,100	3,784	800	8,370	1,025	4,700	....
Wilmington, N. C...	....	1,890	....	650	1,260	1,400	....	1,550
New Orleans.......	2,400	....	1,700	....	2,100	....	3,340	....
Other ports........	800	3,700	1,880	2,380	7,975	1,290	4,883	600
Total........	47,285	58,488	48,602	50,625	81,342	43,381	82,814	35,323

NEW FOREIGN SOURCES.

During 1897 considerable exploitation work was carried on upon some deposits in Lower California (Mexico), about 1,000 tons of ore being produced, and which was ready for shipment on the 1st of January, 1898. The operations are being conducted by American capitalists, who have formed a corporation under the title of the American Sulphur Company, with main office in Pittsburg, Pennsylvania, and branch office in

Yuma, Arizona. The deposit is said to be only 7 miles from the Colorado River, near where it empties into the Gulf of California, to which the building of a railroad is contemplated. Shipments to western United States markets can be made via river barges to Yuma and distributed from there by rail. Eastern shipments can be made by sailing vessels through the Gulf. The method of mining the ore is said to be simple. Wagons are driven into the deep, vertical cuts, the walls of which are of sulphur, and the ore is simply broken down and loaded in the wagons below by means of chutes. Very little time is required to load a 2-ton wagon, and another immediately takes its place.

Interest has also been aroused in the contemplated development of sulphur localities in the crater of Orizaba Peak, between the City of Mexico and Vera Cruz. This peak is said to be the highest on the American continent, having an altitude of 17,372 feet. European capitalists are reported to be considering the purchase of some of the sulphur beds convenient to railways.

According to reports in the technical papers, sulphur beds in the island of New Zealand are being actively exploited. The beds are located at Tikitere, about 10 miles from Rotorua. The development of this industry has been due to the high prices of Sicilian sulphur. About 200 persons are employed in mining the sulphur and preparing it for export. The product is shipped in bags to acid makers in Auckland and Sydney.

PYRITES.

PRODUCTION.

The substitution of iron pyrites for sulphur in the manufacture of sulphuric acid continues to increase. This is abundantly shown by the growth of the pyrites-mining industry in this country and the increased use of imported pyrites. The production of pyrites in 1897 amounted to 143,201 long tons of 2,240 pounds, against 115,483 tons in 1896, a gain of 27,718 tons, or 24 per cent. The output in 1896 was the largest up to that time, being nearly 16,000 tons more than in 1895 and nearly 6,000 in excess of the product in 1892, in which year the largest previous production was reported. In sixteen years the production of pyrites for acid making has grown from 12,000 to 143,201 tons, and this has been in the face of steadily growing importations. It is not possible to trace the import statistics further back than 1884, as pyrites previous to that year was classed as and included with sulphur ores. In 1888, 1889, and 1890 under a new classification pyrites was included among other iron ores. In the four years from 1884 to 1887, inclusive, the imports of iron pyrites were insignificant, averaging a little over 10,000 tons per year. In 1891, two years later, the imports had jumped to 100,648 tons, and during the four years 1890 to 1893 they averaged about 153,000 tons per year. In the last three years the average annual imports amounted to 216,716 tons. Dividing the period of sixteen years of which there is any record of domestic production (1882 to 1897) into four equal parts, we find that from 1882 to 1885, inclusive, the total production was 121,000 long tons, an average of 30,250 tons per year. In the next four years the total output was 255,036 tons, a yearly average of 63,759 tons. From 1890 to 1893, inclusive, the total production was 391,955 tons, or an average of 97,989 tons per year. In the last four years the total production has been 464,173 and the average production per year 116,043 tons. This steady and rapid growth in the domestic production of pyrites, and the coincident increase in the imports, are clearly indicative of the growing sentiment in favor of iron pyrites as a source of acid making by American manufacturers and the tendency to make themselves independent of the Anglo-Sicilian syndicate.

The increasing use of pyrites is not confined to the United States. England, Germany, and France are now large consumers. Spain is one of the most important sources of supply for the European market, and furnishes a large percentage of the pyrites imported into the United States. France produced in 1896 295,325 long tons of pyrites, valued at $687,273, and averaged about 245,000 tons in the five years from 1891 to 1895, inclusive.

The Revista Minera de Espana reports the amount of pyrites exported from Spain (the principal source of this ore) in 1895 to have been 480,255 long tons. Four years before, in 1891, the exports were 279,161 long tons. In 1892 they were 435,906 long tons; in 1893, 393,453 long tons; in 1894, 511,769 long tons, and 480,255 long tons in 1895. These are the latest figures available. The figures of production which have been published (100,000 metric tons in 1896) are evidently erroneous.

The reports of production in and exports of pyrites from Spain show unreconcilable figures. As the export statistics are probably obtained from the customs house, they are considered more reliable, and are presented in the following table, together with the amount produced in the United States, Canada, and France. These cover practically all of the pyrites output of the world. In connection with this table is given an estimate of the amount of sulphur displaced in the markets of the world by the use of iron pyrites.

World's product of iron pyrites and amount of sulphur displaced. (*a*)

Countries.	1891.	1892.	1893.	1894.	1895.	1896.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Spain (*b*)	279, 161	435, 906	393, 453	511, 769	480, 255	....
France	243, 030	226, 304	227, 288	278, 452	248, 934	295, 325
United States	106, 536	109, 788	75, 777	105, 940	99, 549	115, 483
Canada	60, 474	53, 372	52, 270	36, 185	30, 534	30, 103
Total	689, 211	1, 005, 370	748, 788	932, 346	859, 272	....
Sulphur displaced	310, 145	452, 416	336, 955	419, 556	386, 672	....

a Based on estimated 45 per cent of sulphur contents. *b* Exports only.

The amount and value of pyrites mined for sulphur contents in the United States since 1882 have been as follows:

Production of pyrites in the United States from 1882 to 1897.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1882..........	12,000	$72,000	1890...........	99,854	$273,745
1883..........	25,000	137,500	1891...........	106,536	338,880
1884..........	35,000	175,000	1892...........	109,788	305,191
1885..........	49,000	220,500	1893...........	75,777	256,552
1886..........	55,000	220,000	1894...........	105,940	363,134
1887..........	52,000	210,000	1895...........	99,549	322,845
1888..........	54,331	167,658	1896...........	115,483	320,163
1889..........	93,705	202,119	1897...........	143,201	391,541

IMPORTS.

The following table shows the imports of pyrites containing not more than 3.5 per cent of copper from 1884 to 1897:

Imports of pyrites containing not more than 3.5 per cent of copper from 1884 to 1897. (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1884..........	16,710	$50,632	1893...........	194,934	$721,699
1885..........	6,078	18,577	1894...........	163,546	590,905
1886..........	1,605	9,771	1895...........	190,435	673,812
1887..........	16,578	49,661	1896...........	200,168	648,396
1891..........	100,648	392,141	1897...........	259,546	747,419
1892..........	152,359	587,980			

[a] Previous to 1884 classed among sulphur ores; 1887 to 1891 classed among other iron ores; since 1891 includes iron pyrites containing 25 per cent and more of sulphur.

CONSUMPTION.

As the imports of iron pyrites for use in the manufacture of sulphuric acid were not stated separately by the Bureau of Statistics of the Treasury Department prior to 1891, a comparison with the preceding years can not be made. The following table shows the amount of pyrites mined and imported for the past five years, and as no exports are reported by the Treasury Department, these figures may be accepted as representing the domestic consumption. The table also shows the estimated amount of sulphur displaced each year on a basis of 45 per cent of sulphur contents.

Amount of pyrites consumed in the United States, and estimated sulphur displaced, from 1891 to 1897.

Source.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Domestic product..	106, 536	109, 788	75, 777	105, 940	99, 549	115, 483	143, 201
Imports	100, 648	152, 359	194, 934	163, 546	190, 435	200, 168	259, 546
Domestic consumption ...	207, 184	262, 147	270, 711	269, 486	289, 984	315, 651	402, 747
Sulphur displaced estimated on basis of 45 per cent contents	93, 233	117, 966	121, 815	121, 269	130, 493	142, 097	181, 236

INCREASED CONSUMPTION OF PYRITES "FINES."

In the earlier days of pyrites mining the impression prevailed that only the larger pieces of ore could be utilized in the roasting furnaces for making sulphuric acid, and the small stuff or "fines" was considered a waste product. Hence it was that although millions of tons of granular or "fines" pyrites have been mined during the last thirty-five years, no practical process for the burning or roasting of the same (to utilize the contained sulphur) was introduced until about the year 1880, when Peter Spence, in England, succeeded in mechanically producing a result which up to that time had been produced only in a moderately successful manner by shelf furnaces, of which there were several types. Since that date (1880) the opening of the American mines has made it necessary to have some mechanical furnace that would consume the "fines," and that would enable the producers to market the larger portion of their mine products, as it is well known that an average of at least 60 per cent of all American pyrites ores is in granular form when mined.

In the year 1883 the Spence mechanical furnace was introduced in the United States by Mr. William H. Adams, and in that year 3,000 tons of granular pyrites were burned. During the years which have succeeded this introduction the American mines have produced probably 400,000 tons of this class of ore, and there has been imported over one-half as much more, showing that constantly improved processes have been devised for the purpose of working "fines," and have been the means of marketing a mine product once supposed to be worthless.

For the year 1897 the consumption of granular ores in the United States was not less than 100,000 tons, and the changes now being made in nearly all of the chemical plants of this country are intended to utilize granular pyrites in place of brimstone, and in several places in place of lump pyrites ores.

It is now possible to construct a mechanical furnace at a cost of $1,500, which will perfectly roast 7,000 pounds of granular ore in twenty-four hours. Such a furnace requires but little attention and no extra cost for labor, thus meeting the many objections put forward by chemical manufacturers for the last twenty years. Larger furnaces, which will roast 25,000 pounds of American ores daily, are constructed at a cost of $3,000. This mechanical operation solves many of the disagreeable problems which faced the owners of chemical works, and it is not impossible that we shall see granular ores, or "fines," and mechanical furnaces supplanting lump-ore and other forms of furnaces for the production of sulphurous acid gas made from pyrites ores.

OCCURRENCES IN THE UNITED STATES.

Iron pyrites is found in nearly every one of the United States, but it has not been mined on a commercial scale in more than six. The larger portion of the output comes from Louisa County, Virginia. Next in importance are the Davis mines in Franklin County, Massachusetts. Prince William County is another producing locality in Virginia. Ninety per cent of the production is obtained from these three localities. Some pyrites ore was produced in Tennessee in 1897, and about 10,000 tons used in the manufacture of sulphite pulp were mined in New York. Ohio is credited with a small product obtained in a "sulphur band" occurring in a coal seam. It is separated from the coal and shipped to acid makers in Cleveland. Deposits in the vicinity of Hot Springs, Arkansas, mention of which has been made in previous reports, are being exploited.

CANADIAN PRODUCTION.

While the production and consumption of pyrites in the United States have been steadily increasing, production in Canada has been steadily declining for several years, the production in 1896 being less than half of what it was in 1891, and about 45 per cent of the product in 1889. Since 1886 the production of pyrites in Canada has been as follows:

Annual production of pyrites in Canada since 1886.

Calendar year.	Tons of 2,000 lbs.	Value.
1886	42,906	$193,077
1887	38,043	171,194
1888	63,479	285,656
1889	72,225	307,292
1890	49,227	123,067
1891	67,731	203,193
1892	59,770	179,310
1893	58,542	175,626
1894	40,527	121,581
1895	34,198	102,594
1896	33,715	101,155
1897	38,910	116,730

GYPSUM.

By **Edward W. Parker.**

OCCURRENCE.

Large deposits of gypsum are found in many of the United States. East of the Mississippi River the principal localities are in New York, where it occurs in beds of great thickness and extent in a line of counties extending westward from Oneida to Niagara; in Ohio, near the city of Sandusky; in Michigan, on the Grand River, near Grand Rapids, and at Alabaster Point, Iosco County, and in Bay County; in Virginia, along the north fork of the Holston River, and in Smyth and Washington counties. Gypsum is also reported in Alabama and Louisiana, but the deposits are not worked at the present time. West of the Mississippi River and east of the Rocky Mountains extensive gypsum deposits are found in Iowa, Kansas, Arkansas, Texas, Oklahoma, and the Indian Territory. Operations are carried on in Webster County, Iowa; Barber, Saline, Marion, Marshall, and Dickinson counties, Kansas; at Quanah, Texas, and at Okarche, Oklahoma.

The Rocky Mountain States producing gypsum are Colorado, Montana, Utah, South Dakota, and Wyoming, and deposits are reported in Idaho and New Mexico. Extensive stratified deposits of gypsum occur in the Santa Rita range of mountains in Pima County, southern Arizona. These deposits have not been worked, as they are remote from transportation facilities and the country is not sufficiently settled to furnish a profitable market.

Some work has been done on another deposit of gypsum in the Sierritas, about 18 miles south of Tucson, Arizona. The material was shipped to Tucson and calcined into plaster of paris. About 30 tons of crude gypsum were produced in 1897.

California contributes the entire product of the Pacific States. Deposits exist in several parts of the State, notably in Fresno, Monterey, and San Benito counties. Gypsum deposits of considerable extent exist on both sides of Snake River, in eastern Oregon. A mill erected in 1896 at Huntington for calcining the product was destroyed by fire before any commercial output had been obtained. Rebuilding was in progress at the opening of 1898.

PRODUCTION.

The amount of gypsum produced in the United States in 1897 exceeded that of any previous year, reaching a total of 288,982 short tons, against 224,254 short tons in 1896. Previous to 1897 the largest production obtained was in 1895, when the output aggregated 265,503 short tons. The product in 1897 was 64,728 short tons, or 29 per cent, more than that of 1896, and 23,479 short tons, or 9 per cent, more than the output in 1895.

Reckoning the value of the product according to the condition in which it was first placed upon the market, the gypsum output in 1897 was worth $755,864, an average price per ton of $2.62, against $2.55 in 1896 and $3 in 1895. There were three years (1889, 1894, and 1895) in which the value of the output exceeded that of 1897.

The increased production in 1897 was participated in by all but one of the principal producing States. Iowa and Kansas each had an increased production. The statistics of the production in these two States for 1897 are combined. Their aggregate output in 1897 was 83,783 short tons, against 68,066 tons in 1896; Michigan's production increased from 67,634 short tons to 94,874 tons; the product of New York increased from 23,325 to 33,440 tons; Texas from 16,022 to 24,454 tons, and Virginia from 5,955 to 6,374 tons. Ohio's output decreased slightly.

The details of production, by States, for the last two years are shown in the following tables:

Product of gypsum in the United States in 1896, by States.

State.	Total product.	Sold crude.		Ground into land plaster.		Calcined into plaster of paris.			Total value.
		Quantity.	Value.	Quantity.	Value.	Before calcining.	After calcining.	Value.	
	Short tons.	*Short tons.*		*Short tons.*		*Short tons.*	*Short tons.*		
California	1,452	100	$463	506	$4,220	846	706	$7,055	$11,738
Colorado	1,600	....	....	....	....	1,600	1,287	10,547	10,547
Iowa	18,631	15	15	637	650	17,979	14,285	33,355	34,020
Kansas	49,435	42	63	250	500	49,143	37,214	147,808	148,371
Michigan	67,634	700	875	6,582	9,133	60,352	46,921	136,416	146,424
New York	23,325	10,256	6,177	13,069	26,635	....	....	....	32,812
Virginia	5,955	115	195	4,640	13,710	1,200	966	3,359	17,264
Other States (*a*)	56,222	6,074	11,346	1,070	4,901	48,478	36,126	155,921	172,168
Total	224,254	17,302	19,134	27,354	59,749	179,598	137,505	494,461	573,344

a Includes the product of Indian Territory, 8,000 tons; Montana, 385 tons; Ohio, 22,634 tons; South Dakota, 6,115 tons; Texas, 16,022 tons; Utah, 2,866 tons; and Wyoming, 200 tons. The distribution of the output in these States and the value are combined in order to maintain the confidential nature of individual reports, there being only one or two operators in each State.

Product of gypsum in the United States in 1897, by States.

State.	Total product.	Sold crude.		Ground into land plaster.		Calcined into plaster of paris.			Total value.
		Quantity.	Value.	Quantity.	Value.	Before calcining.	After calcining.	Value.	
	Short tons.	*Short tons.*		*Short tons.*		*Short tons.*	*Short tons.*		
Colorado and Indian Territory.	12,309	....	....	1	$5	12,306	9,300	$50,350	$50,355
Iowa Kansas	83,783	589	$1,151	500	400	82,694	62,657	253,028	254,579
Michigan	94,874	16,001	20,004	7,193	9,662	71,680	59,340	163,910	193,576
New York	33,440	5,394	3,516	15,826	34,368	12,220	9,200	40,800	78,684
South Dakota	8,350	....	....	....	....	8,350	6,280	19,240	19,240
Texas	24,454	....	....	....	....	24,454	16,412	65,651	65,651
Virginia	6,374	160	257	5,504	14,804	710	592	1,838	16,899
Other States (*a*)	25,398	1,020	2,092	2,538	7,844	21,840	17,154	66,944	76,880
Total	288,982	23,164	27,020	31,562	67,083	234,256	180,935	661,761	755,864

a Includes the product of Arizona, 30 tons; California, 351 tons; Montana, 425 tons; Ohio, 18,592 tons; Utah, 2,700 tons, and Wyoming, 3,300 tons.

An interesting feature of the gypsum industry during the last few years has been the increase in the production of calcined plaster, or plaster of paris. The total amount of gypsum produced in 1897 was only 21,213 short tons, or about 8 per cent more than the product in 1889, eight years before. The amount of calcined plaster made in 1897, however, was nearly three times that of 1889. The production of gypsum in 1889 was unusually large, an increased demand for land plaster having been created by an exceptionally dry summer season. The amount of gypsum sold in the crude in 1889 was 73,243 short tons. A large part of this was afterwards converted, by grinding, into land plaster. The amount converted into land plaster before marketing during that year was 108,771 short tons, so that the total amount of gypsum sold crude and as land plaster in 1889 was about 180,000 short tons. The amount of calcined plaster made in 1889 was 64,711 short tons, in order to produce which 85,755 tons of crude gypsum were consumed. In 1890 the amount of gypsum sold crude and as land plaster fell off to about 75,000 short tons, and decreased about 5,000 tons more in 1891. The next year, 1892, the crude gypsum and land plaster amounted to over 105,000 short tons, and decreased to 93,500 tons in 1893. The next three years these items showed regular decreases, until in 1896 the amount of crude gypsum sold was 17,302 short tons, and the amount of land plaster 27,354, each being about 25 per cent of the quantities so sold in 1889.

The production of gypsum in all lines increased during 1897, the sales of crude amounting to 23,164 short tons and the sales of land plaster to 31,562 short tons. It will be observed in the next table that the average price per ton for crude gypsum shows considerable variation, ranging from $1.02 in 1890 to $1.67 in 1893. In cases where the average price appears unusually high, a considerable portion of the crude gypsum has been sold for subsequent calcination and is of a grade superior to that used only for land plaster. The consumption of land plaster depends very much upon the weather conditions. A summer season of drought will increase the demand, while a wet season will have the opposite effect. The average price varies considerably, according to the States affected, the product in some States being of better quality than that of others and commanding higher prices.

In the production of gypsum for calcined plaster there has been but one exception to a steadily increasing annual output since 1889, though there have been two years in which the amount of calcined plaster made was less than in the preceding years. In 1891 the amount of gypsum calcined was 136,727 short tons, yielding 110,006 short tons of plaster of paris, while in 1892 150,511 tons of crude gypsum produced only 106,141 short tons of plaster. In 1896 the amount of plaster of paris produced from native gypsum was 137,505 short tons, about 13,000 tons less than the product in 1895. With the two exceptions mentioned, the output of plaster of paris from mills using native gypsum rock has increased steadily. The average annual increase has been at the rate of about 14,000 short tons. But while the production has shown such a notable increase, the value of the product has by no means kept pace with it. The increase in output has been attended by a falling off in the price nearly as regular. While the production in 1897 was nearly three times that of 1889, the average price per ton has been almost cut in half. The 180,935 tons of calcined plaster produced in 1897 yielded to the manufacturers a little less than 50 per cent more than the 64,711 tons produced in 1889. The average price per ton for calcined plaster has declined in eight years from $6.92 to $3.60.

The history of gypsum production, the manufacture of calcined plaster, etc., in the last nine years is shown in the following table:

Distribution of the gypsum product of the United States since 1889.

Year.	Total amount produced.	Sold crude.			Ground into land plaster.		
		Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
	Short tons.	*Short tons.*			*Short tons.*		
1889......	267,769	73,243	$82,704	$1.13	108,771	$233,307	$2.14
1890......	182,995	18,742	19,148	1.02	56,525	143,014	2.52
1891......	208,126	18,574	28,690	1.54	51,700	117,356	2.25
1892......	256,259	58,080	80,797	1.39	47,668	106,247	2.23
1893......	253,615	43,108	72,010	1.67	50,408	106,365	2.11
1894......	239,312	34,702	56,149	1.62	41,996	95,944	2.29
1895......	265,503	26,624	37,837	1.42	35,079	85,355	2.43
1896......	224,254	17,302	19,134	1.11	27,354	59,749	2.18
1897......	288,982	23,164	27,020	1.17	31,562	67,083	2.13

Distribution of the gypsum product of the United States since 1889—Continued.

Year.	Calcined into plaster of paris.				Total value.
	Weight before calcining.	Calcined plaster produced.	Value.	Average price per ton.	
	Short tons.	*Short tons.*			
1889	85,755	64,711	$448,107	$6.92	$764,118
1890	105,676	79,257	412,361	5.20	574.523
1891	136,727	110,006	482,005	4.38	628,051
1892	150,511	106,141	508,448	4.79	695,492
1893	160,399	122,937	518,390	4.21	696,615
1894	162,614	127,158	609,626	4.79	761.719
1895	203,800	150,801	674,255	4.47	797,447
1896	179,598	137,505	494,461	3.60	573,344
1897	234,256	180,935	662,311	3.60	755,864

The total production and value, by States, for the same period were as follows:

Comparative statistics of gypsum production for nine years.

State.	1889.		1890.		1891.	
	Product	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Colorado	7,700	$28,940	4,580	$22,050	....	....
Iowa	21,789	55,250	20,900	47,350	31,385	$58,095
Kansas	17,332	94.235	20,250	72,457	40,217	161,322
Michigan	131,767	373,740	74,877	192.099	79,700	223,725
New York	52,608	79,476	32,903	73,093	30,135	58,571
South Dakota	320	2,650	2,900	7,750	3,615	9,618
Virginia	6,838	20,336	6,350	20,782	5,959	22,574
Other States	29,420	109,491	20,235	138,942	17,115	94,146
Total	267,769	764,118	182,995	574,523	208,126	628,051

State.	1892.		1893.		1894.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Iowa	(*a*)	(*a*)	21,447	$55,538	17,906	$44,700
Kansas	46,016	$195,197	43,631	181,599	64,889	301,884
Michigan	139,557	306,527	124,590	303,921	79,958	189,620
New York	32,394	61,100	36,126	65,892	31,798	60,262
Ohio	(*a*)	(*a*)	(*a*)	(*a*)	20,827	69,597
South Dakota	....	....	5,150	12,550	4,295	16,050
Texas	....	....	....	....	6,925	27,300
Virginia	6,991	28,207	7,014	24,359	8,106	24,431
Other States	31,301	104,461	15,657	53,256	4,608	27,875
Total	256,259	695,492	253,615	696,615	239,312	761,719

a Included in other States.

Comparative statistics of gypsum production for nine years—Continued.

State.	1895.		1896.		1897.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
California	5, 158	$51, 014	1, 452	$11, 738	(*a*)	(*a*)
Colorado	1, 371	8, 281	1, 600	10, 547	*b* 12, 309	$50, 855
Iowa	25, 700	36, 600	18, 631	34, 020	83, 783	255, 129
Kansas	72, 947	272, 531	49, 435	148, 371		
Michigan	66, 519	174, 007	67, 634	146, 424	94, 874	193, 576
New York	33, 587	59, 821	23, 325	32, 812	33, 440	78, 684
Ohio	21, 662	71, 204	(*a*)	(*a*)	(*a*)	(*a*)
South Dakota	6, 400	20, 600	(*a*)	(*a*)	8, 350	19, 240
Texas	10, 750	36, 511	(*a*)	(*a*)	24, 454	65, 651
Virginia	5, 800	17, 869	5, 955	17, 264	6, 374	16, 899
Other States	15, 609	50, 009	56, 222	172, 168	25, 398	76, 880
Total	265, 503	797, 447	224, 254	573, 344	288, 982	755, 864

a Included in other States. *b* Including Indian Territory.

The following table shows the annual production of gypsum in the United States since 1880. It will be noticed that the largest production prior to 1897 was in 1889, though the value of the product in both these years was less than that of 1895:

Production of gypsum in the United States since 1880.

Year.	Product.	Value.	Year.	Product.	Value.
	Short tons.			*Short tons.*	
1880	90, 000	$400, 000	1889	267, 769	$764, 118
1881	85, 000	350, 000	1890	182, 995	574, 523
1882	100, 000	450, 000	1891	208, 126	628, 051
1883	90, 000	420, 000	1892	256, 259	695, 492
1884	90, 000	390, 000	1893	253, 615	696, 615
1885	90, 405	405, 000	1894	239, 312	761, 719
1886	95, 250	428, 625	1895	265, 503	797, 447
1887	95, 000	425, 000	1896	224, 254	573, 344
1888	110, 000	550, 000	1897	288, 982	755, 864

IMPORTS.

The imports of gypsum are chiefly from Canada, the product from the Dominion being very pure and well adapted for the manufacture of plaster of paris. The following table exhibits the total amount and value of gypsum imported into the United States since 1867:

Gypsum imported into the United States from 1867 to 1897.

Year ended—	Ground or calcined.		Unground.		Value of manufactured plaster of paris.	Total value.
	Quantity.	Value.	Quantity.	Value.		
	Long tons.		*Long tons.*			
June 30, 1867....	....	$29,895	97,951	$95,386	....	$125,281
1868....	....	33,988	87,694	80,362	....	114,350
1869....	....	52,238	137,039	133,430	$844	186,512
1870....	....	46,872	107,237	100,416	1,432	148,720
1871....	....	64,465	100,400	88,256	1,292	154,013
1872....	....	66,418	95,339	99,902	2,553	168,873
1873....	....	35,628	118,926	122,495	7,336	165,459
1874....	....	36,410	123,717	130,172	4,319	170,901
1875....	....	52,155	93,772	115,664	3,277	171,096
1876....	....	47,588	139,713	127,084	4,398	179,070
1877....	....	49,445	97,656	105,629	7,843	162,917
1878....	....	33,496	89,239	100,102	6,989	140,587
1879....	....	18,339	96,963	99,027	8,176	125,542
1880....	....	17,074	120,327	120,642	12,693	150,409
1881....	....	24,915	128,607	128,107	18,702	171,724
1882....	5,737	53,478	128,382	127,067	20,377	200,922
1883....	4,291	44,118	157,851	152,982	*a*21,869	218,969
1884....	4,996	42,904	166,310	168,000	....	210,904
1885....	6,418	54,208	117,161	119,544	....	173,752
1886....	5,911	37,642	122,270	115,696	....	153,338
1887....	4,814	37,736	146,708	162,154	....	199,890
Dec. 31, 1888....	3,340	20,764	156,697	170,023	....	190,787
1889....	5,466	40,291	170,965	179,849	....	220,140
1890....	7,568	55,250	171,289	174,609	....	229,859
1891....	9,560	97,316	110,257	129,003	....	226,319
1892....	6,882	75,608	181,104	232,403	....	308,011
1893....	3,363	31,670	164,300	180,254	....	211,924
1894....	2,027	16,823	162,500	179,237	....	196,060
1895....	3,295	21,526	192,549	215,705	10,352	247,583
1896....	3,292	21,982	180,269	193,544	11,722	227,248
1897....	2,664	17,028	163,201	178,686	16,715	212,429

a Not specified from 1883 to 1894.

CANADIAN PRODUCTION AND EXPORTS.

As the imports of gypsum into the United States are principally from the Provinces of Ontario, New Brunswick, and Nova Scotia, in the Dominion of Canada, the following table, showing the production in and the exports from the Dominion, will be found interesting:

Production and exports of Canadian gypsum since 1886.

Year.	Production.		Exports.	
	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*	
1886	162,000	$178,742	142,833	$155,213
1887	154,008	157,277	132,724	146,543
1888	175,887	179,393	125,508	121,389
1889	213,273	205,108	178,182	194,404
1890	226,509	194,033	175,691	192,254
1891	203,545	192,096	172,496	184,977
1892	226,568	225,260	175,518	194,304
1893	192,568	196,150	*a* 176,489	178,979
1894	223,631	202,031	162,412	160,082
1895	226,178	202,608	*a* 160,898	156,897
1896	207,032	178,061	....	....
1897	239,691	244,531	....	....

a Entire exports went to the United States.

CEMENT PLASTER.

Under the general head of calcined plaster, or plaster of paris, in these reports is included the product of cement plaster made from gypsum dirt, or "gypsite." A greater portion of the gypsum product of Kansas and Texas is of this variety. Mr. G. P. Grimsley, of the Geological Survey of Kansas, has devoted considerable attention to the study of the deposits in that State. He describes them as secondary deposits of gypsum. The material is a granular dirt found in low swampy ground, and is dark colored in place, but on drying assumes a light ash-gray hue. It is soft and incoherent, readily shoveled into cars or wagons, and is ready for calcining with less labor and expense than is required for working the solid rock. Four deposits of this material have been opened in Dickinson County, in the central portion of the State; one is worked in Clay County to the north, and extensive operations are carried on at Quanah, Texas, where similar deposits occur.

Mr. Grimsley states that these dirt deposits undoubtedly belong to the earthy variety of gypsum called by the Germans "gyps-erde" or "Himmel's mehl;" "Himmel's mjoel," by the Swedish; and "gipsowaya muka" by the Russians. These varieties are described as loose, slightly cohering, dust-like particles, of yellow or gray color.

Under the microscope the gypsite of Kansas is seen to consist of a mass of small, angular gypsum crystals of varying size. Perfect crystals are found, but most of them have their terminations somewhat rounded by solution. They are not transported crystals, but have clearly crystallized in place. Mingled with the gypsum crystals, small crystals of quartz are usually found. There is also a considerable amount of lime carbonate, poorly crystallized, and traces of organic matter.

WORLD'S PRODUCTION.

The United States is the second country in the world as a producer of gypsum. France leads with more than one-half the entire world's production. Canada follows the United States in importance, though in one year (1896) the output of Great Britain exceeded that of Canada.

The following table exhibits, in short tons, the amount of gypsum produced by the principal countries of the world in each year, for which statistics are available, since 1893:

The world's production of gypsum since 1893.

Year.	United States.		Great Britain.		Canada.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1893	253,615	$696,615	158,122	$287,940	192,568	$196,150
1894	239,312	761,719	169,102	321,822	223,631	202,031
1895	265,503	797,447	196,037	348,400	226,178	202,608
1896	224,254	573,344	213,028	361,509	207,032	178,061
1897	288,982	756,414	....	....	239,691	244,531

Year.	France.		German Empire.		India.		Cyprus.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1893	....	....	......	....	......	......	2,357	$6,625
1894	1,693,831	$2,891,365	......	....	3,548	$1,566	3,104	9,006
1895	2,175,448	3,392,768	23,994	$11,040	7,511	2,987	2,093	5,252
1896	1,866,498	2,661,200	31,736	14,598	8,248	3,130	......	......
1897	....	....	......	....	......	......	......	......

SALT.

BY EDWARD W. PARKER.

PRODUCTION.

In the production of salt the year 1897 was phenomenal, exceeding by more than 2,000,000 barrels the record for 1896, which was the year of largest previous production. In fact, the domestic production of this indispensable article has shown an increase every year since 1883, with the exception of 1889, when the product was about 0.6 per cent less than in 1888. The growth of the salt industry in this country during the last few years has been remarkable. The total product in 1897 was nearly double that of 1889, and was nearly three times that of 1883. This increase has been in the face of and is no doubt responsible for very low prices. Taking into consideration all of the various grades of salt produced, from the fancy table and dairy grades to the cheap "coarse solar," the average price received by producers in 1896 and 1897 was 30 cents per barrel of 280 pounds, only a fraction over 10 cents per 100 pounds. In 1895 the average price obtained was 32 cents, and in 1894 36½ cents per barrel. From 15 to 16 per cent of the total product is table and dairy salt, the manufacturers in the United States for the last few years having given special attention to the preparation of these fine grades. Their efforts have been crowned with marked success so far as the high quality of their product is concerned. Whether or not their remuneration has been in keeping with their enterprise is another question. One important object, however, has been accomplished. It has not been many years since large consumers of salt, who were particularly discriminating as to the quality they used, would have only the English product. To-day the successful competitors in dairy contests at expositions, etc., are those whose products are made with American salt. Manufacturers are not obliged to pack their salt in packages imitating the English wrappers in order to establish its quality. Salt of domestic production is sold on its merits. The use of foreign salt in the United States is confined almost exclusively to cities along the Atlantic seaboard. The producing localities in the United States are 300 or 400 miles from the coast, and the higher cost of rail transportation acts as a protective tariff in favor of foreign salt brought by ocean freight. The effect that the improvements in salt making in the United States have had on the sale of foreign salt is shown in the tables of imports. In 1881 the amount of salt imported into the United States amounted to over 1,000,000,000 pounds, or nearly 4,000,000 barrels, worth over $2,000,000. The domestic product was about 6,200,000 barrels, worth, exclusive of the cost of packages, etc., about $3,000,000. In 1887 the imports had fallen off to about 2,800,000 barrels, worth $1,285,359. A few years before this, in 1883, the now famous Warsaw district in New York was developed, and in 1897 was producing over a million barrels a year. The domestic production of salt in that year was a little over 8,000,000 barrels. In 1897 the domestic product was nearly double that of ten years before, while the imports were only a little more than half in quantity and about 44 per cent in value.

The following tables exhibit the details of the production of salt in the United States during 1896 and 1897 by States and grades:

Production of salt in 1896, by States and grades.

State.	Table and dairy.	Common fine.	Common coarse.	Packer's.	Coarse solar.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
California	41,714	1,429	30,371	22,500	306,250
Kansas	93,174	922,623	4,310	42,250	....
Michigan	152,388	2,954,608	2,400	31,565	13,622
New York:					
Onondaga district	....	64,347	....	....	2,164,071
Warsaw district	961,721	800,055	97,786	....	....
Southern New York and Genesee dist.	387,277	156,826	12,626	60,473	30,000
Rock salt	....	....	....	....	....
Ohio	400,263	1,173,295	83,765	5,035	....
Pennsylvania	715	177,312	19,714	855	....
Utah	70,886	15,657	49,393	357	7,143
West Virginia	5,000	171,921	....	....	....
Illinois, Nevada, Texas, Louisiana, and Virginia	117,271	160,660	....	....	10,000
Total	2,230,409	6,598,733	300,365	163,035	2,531,086

Production of salt in 1896, by States and grades—Continued.

State.	Rock.	Milling.	Other grades.	Total product.	Total value.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	
California	25,714	....	2,143	430,121	$198,963
Kansas	344,608	....	1,642	1,408,607	397,296
Michigan	....	....	9,655	3,164,238	718,408
New York:					
Onondaga district	....	....	....	2,228,418	575,432
Warsaw district	....	....	82,729	1,942,291	729,324
Southern New York and Genesee dist	....	....	10,679	657,881	270,612
Rock salt	1,240,450	....	....	1,240,450	321,313
Ohio	....	....	....	1,662,358	432,877
Pennsylvania	....	....	....	198,596	56,717
Utah	....	133,271	3,093	279,800	96,550
West Virginia	....	....	....	176,921	50,717
Illinois, Nevada, Texas, Louisiana, and Virginia	173,114	....	....	461,045	192,630
Total	1,783,886	133,271	109,941	13,850,726	4,040,839

Production of salt in 1897, by States and grades.

State.	Number of works.	Table and dairy.	Common fine.	Common coarse.	Packer's.
		Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
California	27	69,313	5,000	45,000	12,921
Kansas	9	64,266	796,340	....	533,135
Michigan	53	173,441	3,298,350	190,794	6,660
New York:					
Brine salt	41	1,358,298	994,949	143,796	40,233
Rock salt	2	....	....	....	....
Ohio	11	401,494	1,081,983	87,616	....
Pennsylvania	3	471	144,863	18,953	....
Utah	6	162,214	65,143	11,286	16,429
West Virginia	4	303,400	137,693	800	....
Illinois, Louisiana, Oklahoma, Texas, and Virginia	5	22,381	344,477	17,898	....
Total	161	2,555,278	6,868,798	516,143	609,378

Production of salt in 1897, by States and grades—Continued.

State.	Coarse solar.	Rock.	Other grades.	Total product.	Total value.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	
California	315,014	15,716	7,929	470,893	$162,654
Kansas	....	111,814	32,772	1,538,327	488,022
Michigan	320,986	....	2,994	3,993,225	1,253,403
New York:					
Brine salt	2,839,777	....	95,622	5,472,675	1,948,759
Rock salt	....	1,333,179	....	1,333,179	
Ohio	....	....	4,321	1,575,414	421,757
Pennsylvania	....	....	....	164,287	45,107
Utah	131,571	2,679	15,857	405,179	196,056
West Virginia	....	....	....	441,893	160,129
Illinois, Louisiana, Oklahoma, Texas, and Virginia	7,143	186,071	160	578,130	244,133
Total	3,614,491	1,649,459	159,655	15,973,202	4,920,020

ESTABLISHMENTS AND PROCESSES.

Including the 6 rock-salt mines, of which there are 2 in New York, in Kansas, and 1 each in California and Louisiana, there were 161 establishments in the United States producing salt during 1897, an increase of 1 over 1896. There were 38 works idle in 1897, against 36 idle plants the preceding year. By "idle" works is meant those which have not been abandoned or dismantled, but which are only temporarily shut down and are likely to resume operations under more favorable conditions. There were 8 establishments producing salt in 1896 that were permanently abandoned and put out of existence before the 1st of January, 1898. Against this are placed 11 new works which started producing during 1897. Five establishments changed hands and 1 new plant was in course of construction on the first of the year. What changes have taken place during the last two years are all in evaporating plants. The same rock-salt mines were in operation both years. In the number of evaporating plants Michigan ranks first and New York second, while in amount and value of the product their positions are reversed. California stands third in number of works and fifth in production; Ohio is fourth in number of works and third in production, and Kansas holds the fifth and fourth ranks, respectively. While the total number of establishments in 1897 was only 1 more than in 1896, there were a number of changes among the different States. California had 3 more plants in operation during 1897 than in 1896, and Kansas lost 3.

Michigan, Ohio, and Nevada each lost 1; New York gained 2; Utah gained 1, and a new plant at Rockford, Okla., brings that Territory into the list of salt producers. All the works in Nevada were idle in 1897, and that State is dropped from the list.

Considering the processes employed, it is found that there were 51 solar plants in 1897 and 49 in 1896. California gained 3 and Utah 1. Kansas and Nevada each lost 1. There were 26 establishments using open pans in 1897, against 25 in 1896; works using vacuum pans decreased from 18 to 15, and the works using grainers in 1897 were 74, against 82 in 1896. A number of establishments use more than one process, and the foregoing figures lead to the belief that some are discarding one or another process and depending upon one system. Direct application of artificial heat would appear to be growing in favor, from the fact that plants using direct heat increased from 31 to 36, while steam heating works fell from 91 to 86.

The total number of salt establishments in each State, the processes employed, and the methods of using heat during 1896 and 1897 are shown in the following tables:

Processes employed in evaporating salt from brine in 1896.

State.	Solar.	Open pan.	Vacuum pan.	Kettle.	Grainer.	Heat applied.		Number of works reporting.
						Direct.	By steam.	
California	21	1			1	1	1	23
Illinois					1		1	1
Kansas	1	5	1		5	5	7	10
Michigan	1	5	8		45	4	51	54
Nevada	1							1
New York:								
Onondaga	20			5		5		25
Warsaw		8	4		15	7	13	14
Genesee								
Southern New York								
Ohio		3	5	1	8	6	9	12
Pennsylvania		1			2	1	2	3
Texas	1	1			1	1	1	1
Utah	4	1					1	5
Virginia		1					1	1
West Virginia					4	1	4	4
Total	49	26	18	6	82	31	91	154

Processes employed in evaporating salt from brine in 1897.

State.	Solar.	Open pan.	Vacuum pan.	Kettle.	Grainer.	Heat applied.		Number of works.
						Direct.	By steam.	
California	24	2	....	......	1	2	4	26
Illinois	......	......	....	......	1	1	....	1
Kansas	......	4	1	......	2	5	2	7
Michigan	1	5	9	......	43	6	49	53
New York	20	8	3	5	14	13	14	41
Ohio	......	1	2	1	6	4	8	11
Oklahoma	......	1	....	......	......	1	....	1
Pennsylvania	......	1	....	......	2	1	2	3
Texas	1	1	....	......	1	1	1	1
Utah	5	1	....	......	......	....	2	6
Virginia	......	1	....	......	......	1	....	1
West Virginia	......	......	....	......	4	1	4	4
Total	51	25	15	6	74	36	86	155

NOTE.—Rock-salt mines are not included in the above tables. Of these there were one in California two in Kansas, one in Louisiana, and two in New York.

PRODUCTION IN PREVIOUS YEARS.

Prior to the taking of the tenth United States census, in 1880, there was no attempt made to ascertain the total amount of salt produced in this country. The salt-inspection laws of Michigan and New York have enabled the authorities of those States to preserve a record of the salt production, the history of the former dating from 1860 and of the latter since 1797. Dr. J. P. Hale, of Charleston, West Virginia, compiled for the Centennial Exposition in 1876 a statement of the history of salt making in that State since 1797, but there were several years for which no records of production existed. There are no statistics of the salt production in other States earlier than the Tenth Census. The census report showed a production during 1880 of 29,805,298 bushels, equivalent to 5,961,060 barrels of 280 pounds, valued at $4,829,566. The first volume of Mineral Resources, covering the calendar year 1882, gave the total production in that year at 6,412,373 barrels, valued at $4,320,140. The changes which have taken place in the seventeen years since 1880 are noteworthy. There has been an almost steady increase in the production and an equally regular decrease in values, until in 1897 the product was nearly 2.9 times what it was in 1880, while the total value shows an increase of only 2 per cent. In 1880 the average price per barrel was 81 cents; in 1897 the average price per barrel was 30 cents.

The production of salt, by States, in 1880 and since 1882 is shown in the following statement. There are no records of the production in

1881, but it is safe to assume that the total output was about 6,200,000 barrels. In reporting production some operators use the bushel as a unit of measurement, some adopt the short ton, some the barrel, and others state their production in pounds. For the sake of convenience, as well as on account of the necessity for a uniform unit in tabulation, the product of each State has been reduced to barrels. A barrel of salt contains 280 pounds, and is equal to 5 bushels of 56 pounds. A short ton contains 7$\frac{1}{7}$ barrels.

Comparative table of production of salt in States and Territories from 1880 to 1897.

State or Territory.	1880.		1882.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	2, 485, 177	$2, 271, 913	3, 037, 317	$2, 126, 122
New York	1, 749, 641	1, 107, 760	1, 668, 036	834, 018
Ohio	530, 060	363, 791	400, 000	280, 000
West Virginia	535, 888	380, 369	400, 000	300, 000
Louisiana	62, 400	56, 160	....	....
California	176, 949	120, 650	214, 200	150, 000
Utah	96, 760	60, 280	92, 820	130, 000
Other States and Territories	324, 185	467, 643	600, 000	500, 000
Total	5, 961, 060	4, 829, 566	6, 412, 373	4, 320, 140

State or Territory.	1883.		1884.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	2, 894, 672	$2, 344, 684	3, 161, 806	$2, 392, 536
New York	1, 619, 486	680, 638	1, 788, 454	705, 978
Ohio	350, 000	231, 000	320, 000	201, 600
West Virginia	320, 000	211, 000	310, 000	195, 000
Louisiana	265, 215	141, 125	223, 964	125, 677
California	214, 286	150, 000	178, 571	120, 000
Utah	107, 143	100, 000	114, 285	80, 000
Nevada	21, 429	15, 000	17, 857	12, 500
Illinois, Indiana, Virginia, Tennessee, Kentucky, and other States and Territories (*a*)	400, 000	377, 595	400, 000	364, 443
Total	6, 192, 231	4, 251, 042	6, 514, 937	4, 197, 734

a Estimated.

Comparative table of production of salt in States and Territories from 1880 to 1897—Cont'd.

State or Territory.	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3,297,403	$2,967,663	3,677,257	$2,426,989
New York	2,304,787	874,258	2,431,563	1,243,721
Ohio	306,847	199,450	400,000	260,000
West Virginia	223,181	145,070	250,000	162,500
Louisiana	299,271	139,911	299,691	108,372
California	221,428	160,000	214,285	150,000
Utah	107,140	75,000	164,285	100,000
Nevada	28,593	20,000	30,000	21,000
Illinois, Indiana, Virginia, Tennessee, Kentucky, and other States and Territories (*a*)	250,000	243,993	240,000	352,763
Total	7,038,653	4,825,345	7,707,081	4,825,345

State or Territory.	1887.		1888.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3,944,309	$2,291,842	3,866,228	$2,261,743
New York	2,353,560	936,894	2,318,483	1,130,409
Ohio	365,000	219,000	380,000	247,000
West Virginia	225,000	135,000	220,000	143,000
Louisiana	341,093	118,735	394,385	134,652
California	200,000	140,000	220,000	92,400
Utah	325,000	102,375	151,785	32,000
Kansas	....	....	155,000	189,000
Other States and Territories	250,000	150,000	350,000	143,999
Total	8,003,962	4,093,846	8,055,881	4,374,203

a Estimated.

Comparative table of production of salt in States and Territories from 1880 to 1897—Cont'd.

State or Territory.	1889.		1890.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3, 856, 929	$2, 088, 909	3, 837, 632	$2, 302, 579
New York	2, 273, 007	1, 136, 505	2, 532, 036	1, 266, 018
Ohio	250, 000	162, 500	231, 303	136, 617
West Virginia	200, 000	130, 000	229, 938	134, 688
Louisiana	325, 629	152, 000	273, 553	132, 000
California	150, 000	63, 000	162, 363	57, 085
Utah	200, 000	60, 000	427, 500	126, 100
Kansas	450, 000	202, 500	882, 666	397, 199
Other States and Territories	300, 000	200, 000	300, 000	200, 000
Total	8, 005, 565	4, 195, 412	8, 876, 991	4, 752, 286

State or Territory.	1891.		1892.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3, 966, 784	$2, 037, 289	3, 829, 478	$2, 046, 963
New York	2, 839, 544	1, 340, 036	3, 472, 073	1, 662, 816
Ohio	(*a*)	(*a*)	899, 244	394, 720
West Virginia	(*a*)	(*a*)		
Louisiana	173, 714	102, 375	200, 000	100, 000
California	200, 949	90, 303	235, 774	104, 938
Utah	969, 000	265, 350	1, 292, 471	340, 442
Nevada	60, 799	39, 898	22, 929	22, 806
Kansas	855, 536	304, 775	1, 480, 100	773, 989
Illinois	39, 670	34, 909	60, 000	48, 000
Virginia	70, 442	70, 425	60, 000	50, 000
Pennsylvania			25, 571	10, 741
Texas			121, 250	99, 500
Other States and Territories	811, 507	430, 761		
Total	9, 987, 945	4, 571, 121	11,698,890	5, 654, 915

a Included in "Other States."

Comparative table of production of salt in States and Territories from 1880 to 1897—Cont'd.

State or Territory.	1893.		1894.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3, 057, 898	$888, 837	3, 341, 425	$1, 243, 619
New York	5, 662, 074	1, 870, 084	6, 270, 588	1, 999, 146
Ohio	543, 963	209, 393	528, 996	187, 432
West Virginia	210. 736	68, 222	194, 532	51, 947
Louisiana	191, 430	97, 200	186, 050	86, 134
California	292, 858	137, 962	332, 246	172, 678
Utah	189, 006	130, 075	268, 186	209, 077
Nevada	6, 559	4, 481	3, 670	4, 030
Kansas	1, 277, 180	471, 543	1, 382, 409	529, 392
Illinois	59, 161	30, 168	50, 000	27, 500
Virginia	....	....	64, 222	43, 580
Pennsylvania	280, 343	136, 436	203, 236	83, 750
Texas	126, 000	110, 267	142, 857	101, 000
Total	11,897,208	4, 154, 668	12,967,417	4, 733, 285

State or Territory.	1895.		1896.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3, 343, 395	$1, 048, 251	3, 164, 238	$718, 408
New York	6, 832, 331	1, 943, 398	6, 069, 040	1, 896, 681
Ohio	781, 033	326, 520	1, 662, 358	432, 877
West Virginia	176, 720	63, 041	176, 921	50, 717
Louisiana	159, 771	78, 169	(*a*)	(*a*)
California	318, 935	158, 683	430, 121	198, 963
Utah	294, 485	121, 762	279, 800	96, 550
Nevada	7, 000	5, 600	(*a*)	(*a*)
Kansas	1, 341, 617	483, 701	1, 408, 607	397, 296
Illinois	67, 119	31, 548	(*a*)	(*a*)
Virginia	65, 000	40, 000	(*a*)	(*a*)
Pennsylvania	157, 243	67, 411	198, 596	56, 717
Texas	125, 000	55, 000	(*a*)	(*a*)
Other States	....	....	461, 045	192, 630
Total	13, 669, 649	4, 423, 084	13, 850, 726	4, 040, 839

a Included in "Other States."

Comparative table of production of salt in States and Territories from 1880 to 1897—Cont'd.

State or Territory.	1897.	
	Quantity.	Value.
	Barrels.	
Michigan	3,993,225	$1,253,403
New York	6,805,854	1,948,759
Ohio	1,575,414	421,757
West Virginia	441,893	160,129
California	470,893	162,654
Utah	405,179	196,056
Kansas	1,538,327	488,022
Pennsylvania	164,287	45,107
Louisiana, Illinois, Virginia, and Texas	578,130	244,133
Total	15,973,202	4,920,020

REVIEW OF THE INDUSTRY.

As previously noted, the above tables show that the production of salt in the United States has increased so rapidly that in the last seventeen years the output has nearly trebled, while the value of 16,000,000 barrels of salt in 1897 was less than $100,000 more than the value of the 6,000,000 barrels produced in 1883. Improved methods have enabled producers in this country to place upon the market the best quality of dairy and table salts, and have also lessened materially the cost to the consumer. The development of the improved methods, and particularly the increased production, have, however, been in excess of the market requirements, and the low prices which have prevailed during the last few years have been rather the result of oversupply than the voluntary cheapening of the product by producers. In fact, efforts have been made, and are still being made, to secure an agreement among the producers in the several important districts whereby more remunerative prices may be obtained, or at least to effect a means of protecting themselves against actual loss. Such an agreement is said to have been reached among the producers in Michigan during 1897, and a comparison of the statistics of that year with the preceding one indicates that the agreement was effective. There was no restriction of production. On the other hand, the production in that State shows an increase from 3,164,238 barrels in 1896 to 3,993,225 barrels in 1897, a gain of about 830,000 barrels, or more than 26 per cent. The value of the product increased 75 per cent, from $718,408 to $1,253,403. The average price per barrel obtained for all grades of salt in Michigan during 1896 was 22.7 cents. In 1897 the price per barrel averaged 31.4 cents, an advance of 8.7 cents, or 38 per cent.

There were only two salt-producing States in which the salt product in 1897 was less than in 1896. These exceptions were Ohio and Pennsylvania. The largest percentage of increase was in West Virginia, whose output in 1897 was 2.5 times that of 1896. In the amount of increase Michigan showed the largest gain, with a production of 830,000 barrels over that of 1896. New York increased its product by over 735,000 barrels, coming second in the amount of increase. West Virginia was third in the amount of increased production, and Kansas and Utah were nearly tied for fourth place, the latter leading by about 5,000 barrels.

Referring again to a comparison of the production in 1897 with that of 1880, as shown by the Tenth Census, a striking example of the modern tendency to concentration is shown. By concentration is meant the development of large industries under one management and the retirement from business of smaller producers. According to the Tenth Census there were 268 establishments producing salt in the United States during 1880. As the production in that year was 5,961,000 barrels, this meant an average output by each establishment of a little over 22,000 barrels per year. In 1897, with a total production of practically 16,000,000 barrels, the number of establishments has fallen to 161, indicating an average output for each of nearly 100,000 barrels. In other words, while the number of establishments has fallen off 40 per cent, the total production has increased nearly 200 per cent, and the average output of each establishment in 1897 was nearly five times what it was in 1880.

Another interesting comparison of the industry in 1880 and 1897 may be made. In the former year the amount of salt imported into this country was about 3,430,000 barrels, equivalent to 58 per cent of the domestic production. The imports in 1897 were only about 1,500,000 barrels, about 9 per cent of the domestic production. Adding the imports to the home product and deducting the exports (the exports in 1880 being about 4,400 barrels and in 1897, 54,195 barrels), the domestic consumption in 1880 amounted to about 7,457,000 barrels, which, with a population of 50,156,000, was equivalent to a consumption per capita of 0.15 barrel, or 42 pounds; in 1897 the total consumption was 17,412,040 barrels, which, estimating the population at 72,000,000, would be equivalent to a per capita consumption of 0.242 barrel, or 68 pounds. This increase of about 62 per cent in the per capita consumption may be accounted for by the development in the last two decades of our enormous packing industries in the Western States, the increased dairy products, and the natural larger consumption which always attends lower prices.

The exports of domestic salt have not much influence on the trade, amounting to but 10,853,759 pounds, or 38,763 barrels, in 1894; 7,203,024 pounds, or 25,725 barrels, in 1895; 10,711,314 pounds, or 38,255 barrels, in 1896, and 10,100,712 pounds, or 36,070 barrels, in 1897. To these should be added the exports of foreign salt, imported and reexported. This factor is included in the exports in the following table. The imports added to the domestic product and the exports deducted from the total in the last five years show that the salt consumed or placed upon the market in the United States increased from 13,121,233 barrels in 1893 to 14,479,209 barrels in 1894, to 15,629,764 barrels in 1895, to 15,645,949 barrels in 1896, and to 17,412,040 barrels in 1897. This is illustrated in the following table:

Supply of salt for domestic consumption from 1893 to 1897.

Sources.	1893.	1894.	1895.	1896.	1897.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Domestic product	11,897,208	12,967,417	13,669,649	13,850,726	15,973,202
Imports	1,244,711	1,550,555	1,996,970	1,858,614	1,493,033
Total	13,141,919	14,517,972	15,666,619	15,709,340	17,466,235
Exports	20,686	38,763	36,855	63,391	54,195
Domestic consumption	13,121,233	14,479,209	15,629,764	15,645,949	17,412,040
Increase over preceding year		1,357,970	1,150,555	16,185	1,766,091

IMPORTS AND EXPORTS.

The imports of salt into the United States exhibit an almost constant decrease from 1881 to 1893. The decrease was particularly noticeable in the imports of refined salt, due in great measure to the improvements inaugurated in the manufacture of table and dairy salt by American producers, which has made the domestic product equal if not superior to salt of foreign make. The tariff act of 1894 placed salt upon the free list, and importations have since been larger, increasing from 348,519,173 pounds in 1893 to 434,155,708 pounds in 1894, and to nearly 560,000,000 pounds in 1895. In 1896 the imports of foreign salt amounted to 520,411,822 pounds. The tariff act of 1897 returns salt to the dutiable list. Salt in bags, barrels or other packages is subjected to a duty of 12 cents per 100 pounds (33.6 cents per barrel), and salt in bulk is taxed at the rate of 8 cents per 100 pounds, or 22.4 cents per barrel. The duty on imported salt in bond used in curing fish taken by vessels licensed to engage in the fisheries and in curing fish on the navigable waters of the United States, or on salt used in curing meats for export, may be remitted. The quantity of salt imported in 1897 was nearly 20 per cent less than in 1896, the total amounting to 418,049,214 pounds. Since 1867 the imports have been as follows:

Salt imported and entered for consumption in the United States, 1867 to 1897, inclusive.

Year ended—	In bags, barrels, and other packages.		In bulk.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
June 30, 1867......	254, 470, 862	$696, 570	229, 304, 323	$336, 302
1868......	308, 446, 080	915, 546	219, 975, 096	365, 458
1869......	297, 382, 750	895, 272	256, 765, 240	351, 168
1870......	288, 479, 187	797, 194	349, 776, 433	507, 874
1871......	283, 993, 799	800, 454	274, 730, 573	355, 318
1872......	258, 232, 807	788, 893	257, 637, 230	312, 569
1873......	239, 494, 117	1, 254, 818	388, 012, 132	525, 585
1874......	358, 375, 496	1, 452, 161	427, 294, 209	649, 838
1875......	318, 673, 091	1, 200, 541	401, 270, 315	549, 111
1876......	331, 266, 140	1, 153, 480	379, 478, 218	462, 106
1877......	359, 005, 742	1, 059, 941	444, 044, 370	532, 831
1878......	352, 109, 963	1, 062, 995	414, 813, 516	483, 909
1879......	375, 286, 472	1, 150, 018	434, 760, 132	532, 706
1880......	400, 970, 531	1, 180, 082	449, 743, 872	548, 425
1881......	412, 442, 291	1, 242, 543	529, 361, 041	658, 068
1882......	329, 969, 300	1, 086, 932	399, 100, 228	474, 200
1883......	312, 911, 360	1, 035, 946	412, 938, 686	451, 001
1884......	340, 759, 010	1, 093, 628	441, 613, 517	433, 827
1885......	351, 276, 969	1, 030, 029	412, 322, 341	386, 858
Dec. 31, 1886......	319, 232, 750	966, 993	366, 621, 223	371, 000
1887......	275, 774, 571	850, 069	343, 216, 331	328, 201
1888......	238, 921, 421	620, 425	272, 650, 231	246, 022
1889......	180, 906, 293	627, 134	234, 499, 635	249, 232
1890......	172, 611, 041	575, 260	243, 756, 044	252, 848
1891......	150, 033, 182	492, 144	220, 309, 985	224, 569
1892......	150, 799, 014	488, 108	201, 366, 103	196, 371
1893......	98, 037, 648	358, 575	146, 945, 390	63, 404
1894......	60, 793, 685	206, 229	101, 525, 281	86, 718
1895......	601, 086	1, 723	1, 874, 644	1, 874
1896......	350, 620	814	1, 627, 030	1, 640
1897......	36, 801, 048	114, 072	50, 775, 105	46, 412

Salt imported and entered for consumption in the United States, etc.—Continued.

Year ended—	For the purpose of curing fish.		Not elsewhere specified.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		
June 30, 1867....	....	....	....	....	$1, 032, 872
1868....	....	....	....	....	1, 281, 004
1869....	....	....	....	....	1, 246, 440
1870....	68, 597, 023	$87, 048	....	....	1, 392, 116
1871....	64, 671, 139	66, 008	....	....	1, 221, 780
1872....	57, 830, 929	60, 155	....	....	1, 161, 617
1873....	86, 756, 628	86, 193	....	....	1, 866, 596
1874....	105, 613, 913	126, 896	....	....	2, 228, 895
1875....	110, 294, 440	119, 607	....	....	1, 869, 259
1876....	118, 760, 638	126, 276	....	....	1, 741, 862
1877....	132, 433, 972	140, 787	....	....	1, 733, 559
1878....	100, 794, 611	96, 898	....	....	1, 643, 802
1879....	94, 060, 114	95, 841	....	....	1, 778, 565
1880....	109, 024, 446	119, 667	....	....	1, 848, 174
1881....	133, 395, 065	144, 347	....	....	2, 044, 958
1882....	134, 777, 569	147, 058	....	....	1, 708, 190
1883....	142, 065, 557	154, 671	....	....	1, 641, 618
1884....	126, 605, 276	122, 463	....	....	1, 649, 918
1885....	140, 067, 018	121, 429	....	....	1, 538, 316
Dec. 31, 1886....	103, 360, 362	94, 721	....	....	1, 432, 714
1887....	105, 577, 947	107, 089	....	....	1, 285, 359
1888....	113, 459, 083	111, 120	....	....	977, 577
1889....	97, 960, 624	100, 123	....	....	976, 489
1890....	98, 279, 719	96, 648	....	....	924, 756
1891....	103, 990, 324	89, 196	....	....	805, 909
1892....	105, 192, 086	90, 327	....	....	774, 806
1893....	103, 536, 135	87, 749	....	....	509, 728
1894....	93, 723, 885	79, 482	178, 112, 857	$263, 707	636, 136
1895....	8, 668, 490	12, 195	548, 007, 449	739, 122	754, 914
1896....	8, 351, 913	11, 814	510, 082, 259	687, 890	702, 158
1897....	32, 961, 953	33, 962	297, 511, 108	370, 592	565, 038

Salt of domestic production exported from the United States from 1790 to 1897, inclusive.

Year ended—	Quantity.	Value.	Year ended—	Quantity.	Value.
	Bushels.			*Bushels.*	
Sept. 30, 1790..	31, 935	$8, 236	June 30, 1863..	584, 901	$277, 838
1791..	4, 208	1, 052	1864..	635, 519	296, 088
1830..	47, 488	22, 978	1865..	589, 537	358, 109
1831..	45, 847	26, 848	1866..	70, 644	300, 980
1832..	45, 072	27, 914	1867..	605, 825	304, 030
1833..	25, 069	18, 211	1868..	624, 970	289, 936
1834..	89, 064	54, 007	1869..	442, 947	190, 076
1835..	126, 230	46, 483	1870..	298, 142	119, 582
1836..	49, 917	31, 943	1871..	120, 156	47, 115
1837..	99, 133	58, 472	1872..	42, 603	19, 978
1838..	114, 155	67, 707	1873..	73, 323	43, 777
1839..	264, 337	64, 272	1874..	31, 657	15, 701
1840..	92, 145	42, 246	1875..	47, 094	16, 273
1841..	215, 084	62, 765	1876..	51, 014	18, 378
1842..	110, 400	39, 064	1877..	65, 771	20, 133
June 30, 1843*a*.	40, 678	10, 262	1878..	72, 427	24, 968
1844..	157, 529	47, 755	1879..	43, 710	13, 612
1845..	131, 500	45, 151	1880..	22, 179	6, 613
1846..	117, 627	30, 520	1881..	45, 455	14, 752
1847..	202, 244	42, 333	1882..	42, 085	18, 265
1848..	219, 145	73, 274	1883..	54, 147	17, 321
1849..	312, 663	82, 972	1884..	70, 014	26, 007
1850..	319, 175	75, 103	1885..	*b*4, 101, 587	26, 488
1851..	344, 061	61, 424	Dec. 31, 1886..	4, 828, 863	29, 580
1852..	1, 467, 676	89, 316	1887..	4, 685, 080	27, 177
1853..	515, 857	119, 729	1888..	5, 359, 237	32, 986
1854..	548, 185	159, 026	1889..	5, 378, 450	31, 405
1855..	536, 073	156, 879	1890..	4, 927, 022	30, 079
1856..	698, 458	311, 495	1891..	4, 448, 846	23, 771
1857..	576, 151	190, 699	1892..	5, 208, 935	28, 399
1858..	533, 100	162, 650	1893..	5, 792, 207	38, 375
1859..	717, 257	212, 710	1894..	10, 853, 759	46, 780
1860..	475, 445	129, 717	1895..	7, 203, 024	30, 939
1861..	537, 401	144, 046	1896..	10, 711, 314	43, 202
1862..	397, 506	228, 109	1897*c*.	10, 100, 712	41, 832

a Nine months. *b* Pounds from 1885. *c* Fiscal year ended June 30, 1897.

In connection with the above tables it is interesting to note the sources from which our imported salt is obtained and the markets supplied by our exports of domestic salt. For this purpose the following tables, showing the countries from which we import, the amount and value of the salt received from each, and also the amount and value of the salt exported to each country, are given for the four fiscal years ending

June 30, 1894, 1895, 1896, and 1897. It will be observed that the principal source of supply is the United Kingdom, from which we imported 136,550,196 pounds out of a total of 345,479,066 in 1894, 266,090,597 pounds out of a total of 496,810,501 in 1895, 329,381,633 pounds out of a total of 553,279,500 pounds in 1896, and 314,095,950 pounds out of a total of 598,358,356 pounds in 1897. The imports from Great Britain were about 40 per cent of the total in 1894, more than 50 per cent in 1895, nearly 60 per cent in 1896, and 52 per cent in 1897. Italy exported over 93,000,000 pounds to this country in 1894, and the West Indies nearly 100,000,000 pounds, so that the amount received from these three sources was 329,016,443 pounds, or 95 per cent of the total. In 1895 the imports from Italy fell off to 81,725,686 pounds, while those from the West Indies increased to 137,325,128 pounds. In 1896 the imports from Italy were 78,768,053 pounds, and from the West Indies 136,396,990 pounds. The imports from Italy in 1897 increased to 82,373,539 pounds, and from the West Indies to 187,323,130 pounds. The total from the above three sources was 485,141,411 pounds in 1895, 544,546,676 pounds in 1896, and 583,792,619 pounds in 1897, or about 98 per cent.

The principal exports are through the port of San Francisco, and to the Central American States, Mexico, the Hawaiian Islands, Japan, and Asiatic Russia. About 25 per cent, or a little more, goes across the Great Lakes to the Dominion of Canada.

The imports and exports for the past four fiscal years, with the countries from which imported and to which exported, have been as follows:

Imports of salt during the fiscal years ending June 30, 1894, 1895, 1896, and 1897, with the countries from which exported.

Country from which exported.	Year ending June 30, 1894.		Year ending June 30, 1895.			
			Free.		Dutiable.(a)	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Belgium	10,286	$14	2,020	$30		
France	4,783,980	3,636			1,400	$46
Germany	672,963	1,748			186,413	871
Italy	93,205,163	67,148	65,461,114	42,761	16,264,572	11,388
Portugal	2,572,735	1,833	419,844	348	3,618,272	3,259
Spain	2,349,078	1,596			3,680,272	3,376
United Kingdom:						
England	136,538,796	422,007	244,566,953	431,642	21,523,644	46,025
Scotland	11,400	56				
Canada:						
Nova Scotia, New Brunswick, etc.	4,415,581	9,549	275,400	425	2,297,300	6,528
Quebec, Ontario	1,141,350	6,183	840	7	327,284	1,413

[a] The tariff act of 1894 provided that salt should be free of duty, but when in bags or other packages the coverings should pay duty as if imported separately, and salt imported from countries imposing a duty on salt exported from the United States should pay the rate of duty imposed prior to the act of 1894.

Imports of salt during the fiscal years ending June 30, 1894, etc.—Continued.

Country from which exported.	Year ending June 30, 1894.		Year ending June 30, 1895.			
			Free.		Dutiable. (a)	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Central America:						
Nicaragua	7,500	$50				
Mexico	226,413	387			230,580	$440
West Indies:						
British	93,549,034	72,023	56,993,688	$55,788	50,978,337	40,101
Dutch	4,726,544	5,201	21,726,311	26,073	1,851,386	2,075
French	984,506	993	2,847,905	4.028	1,466,650	1,573
Danish			27,000	45	233,851	243
Puerto Rico					1,200,000	1,618
Brazil	99,853	80				
Hongkong	284	2				4
Portuguese Africa	183,600	216			527,275	361
Hawaiian Islands			100,000	330		
Egypt			2,100	13		
Total	345,479,066	592,722	392,423,175	561,490	104,387,326	119,312

Country from which exported.	Year ending June 30, 1896.			
	Free.		Dutiable. (a)	
	Pounds.	Value.	Pounds.	Value.
Germany	2,010,595	$7,506	356,110	$2,201
Italy	78,768,053	50,511		
Portugal			784,992	581
United Kingdom:				
England Scotland	329,381,449	552,794	184	3
Canada:				
Nova Scotia, New Brunswick, etc	186,667	254	4,083.414	9,354
Quebec, Ontario			194,546	912
British Columbia	4,000	28	58,300	218
Mexico	30	2	717,903	456
West Indies:				
British	115,477,302	110,092		
Dutch	19,309,198	22,357		
French	1,610,490	2,140		
Portuguese Africa			330,870	228
Hawaiian Islands	4,000	40		
Egypt	1,397	19		
Total	546,753,181	745,743	6,526,319	13,953

[a] The tariff act of 1894 provided that salt should be free of duty, but when in bags or other packages the coverings should pay duty as if imported separately, and salt imported from countries imposing a duty on salt exported from the United States should pay the rate of duty imposed prior to the act of 1894. Under the tariff act of 1897 salt in bulk is subject to a duty of 8 cents per 100 pounds; salt in packages, 12 cents per 100 pounds, with duty remitted on salt used in curing meats for export, or in curing fish on the navigable waters of the United States.

Imports of salt during the fiscal years ending June 30, 1894, etc.—Continued.

Country from which exported.	Year ending June 30, 1897.			
	Free.		Dutiable. (*a*)	
	Pounds.	Value.	Pounds.	Value.
France	...	...	6,614	$19
Germany	...	...	2,928,815	4,333
Italy	82,373,539	$53,306	...	...
Portugal	...	...	2,692,635	2,287
Belgium	460	5	...	...
Spain	...	...	1,800,000	1,470
United Kingdom:				
England Scotland	312,975,950	507,972	1,120,000	1,217
Canada:				
Nova Scotia, New Brunswick, etc.	...	...	3,200,697	6,991
Quebec, Ontario	448,000	1,127	227,070	1,047
British Columbia	13,440	67	25,680	126
Mexico	...	...	2,920,576	1,451
West Indies:				
British	170,629,494	156,703	...	...
Dutch	16,693,636	15,539	...	...
Portuguese Africa	...	...	301,750	238
Total	583,184,519	734,719	15,223,837	19,179

[a] The tariff act of 1894 provided that salt should be free of duty, but when in bags or other packages the coverings should pay duty as if imported separately, and salt imported from countries imposing a duty on salt exported from the United States should pay the rate of duty imposed prior to the act of 1894. Under the tariff act of 1897 salt in bulk is subject to a duty of 8 cents per 100 pounds; salt in packages, 12 cents per 100 pounds, with duty remitted on salt used in curing meats for export, or in curing fish on the navigable waters of the United States.

Exports of salt during the fiscal years ending June 30, 1894, 1895, 1896, and 1897, and countries to which exported.

Country to which exported.	Year ending June 30, 1894.		Year ending June 30, 1895.	
	Pounds.	Value.	Pounds.	Value.
United Kingdom	....	....	112,000	$350
Bermuda	....	....	....	....
British Honduras	4,600	$47	2,462	33
Dominion of Canada:				
Nova Scotia, New Brunswick, etc	663,150	5,635	195,900	1,753
Quebec, Ontario, etc	3,743,978	10,245	2,344,683	5,457
British Columbia	748,952	3,574	224,100	1,618
Newfoundland and Labrador	....	....	....	....
Central American States:				
Costa Rica	99,320	735	41,057	535
Guatemala	328,277	1,761	475,040	2,279
Honduras	23,370	422	30,897	412
Nicaragua	208,482	1,749	238,955	2,134
Salvador	1,791,200	8,818	1,405,000	7,241
Mexico	590,640	6,329	810,575	6,652
West Indies:				
British	2,000	15	1,500	12
Dutch and French	....	....	....	....
Haiti	....	....	....	....
Santo Domingo	....	....	....	....
Spanish—Cuba	....	....	....	....
Colombia	11,910	94	7,300	70
Japan	146,000	438	20,000	78
China	....	....	....	....
Russia, Asiatic	2,954,000	8,959	2,180,000	7,340
French Oceanica	79,450	439	69,000	374
British Australasia	....	....	....	....
Hawaiian Islands	495,450	2,811	541,300	2,721
British Africa	....	....	....	....
Other countries	....	....	....	....
Total	11,890,779	52,071	8,699,769	39,059

Exports of salt during the fiscal years ending June 30, 1894, etc.—Continued.

Country to which exported.	Year ending June 30, 1896.		Year ending June 30, 1897.	
	Pounds.	Value.	Pounds.	Value.
United Kingdom			95,000	$1,945
Bermuda	20,375	$205	118,989	1,136
British Honduras	21,615	97	7,330	89
Dominion of Canada:				
Nova Scotia, New Brunswick, etc	20,093	211	20,070	366
Quebec, Ontario, etc	1,393,105	3,042	1,667,317	4,349
British Columbia	373,874	2,690	425,257	3,529
Newfoundland and Labrador	18,150	151	51,870	497
Central American States:				
Costa Rica	33,635	427	45,466	370
Guatemala	129,102	1,152	476,194	2,967
Honduras	859,190	4,490	41,330	540
Nicaragua	183,105	1,603	180,451	1,715
Salvador	66,100	341	99,000	468
Mexico	1,064,276	8,871	480,559	4,529
West Indies:				
British	20,467	210	124,104	649
Dutch and French			2,295	26
Haiti	1,200	13	7,560	96
Santo Domingo	18,325	190	75,274	868
Spanish—Cuba	300	4	52,000	560
Colombia			33,749	275
Japan	125,600	409	250,000	1,181
China	8,500	25		
Russia, Asiatic	4,608,640	12,134	5,206,180	12,444
French Oceanica	143,400	728	102,600	517
British Australasia	24,500	245	52,927	272
Hawaiian Islands	632,000	3,304	462,700	2,223
British Africa			14,000	125
Other countries			5,990	60
Total	9,765,552	40,542	10,100,712	41,832

SALT MAKING IN OKLAHOMA.

In Mineral Resources for 1896 a historical sketch of the salt industry in the United States was published. Another paragraph may now be added which will record the beginning of salt production in the new Territory of Oklahoma. Mr. E. C. Chapman, editor of the Okeene Eagle, reports to the Survey that the salt formation in the Territory is a continuation of the Kansas beds. Seven miles south and west of Okeene are great gypsum hills deeply cut by canyons. The bed of one of these canyons is traversed by a creek strongly impregnated with salt. It is practically a brine creek, flowing eastwardly into the Cimarron River. Salt making was begun in 1896 by a few farmers who took claims bordering on the creek. One of the first attempts made was by Mr. J. M. White, who began evaporating the brine with an ordinary stove kettle and then with a galvanized washtub. As these were soon destroyed by the action of the salt, he experimented with a sorghum pan, meeting with more success. Others adopted the same method, and at the close of 1897 there were four of these primitive plants in operation, with from two to four pans each. Some difficulty was experienced at first in selling the salt, as consumers in the neighborhood were prejudiced against it. Mr. Chapman had analyses made of it at the Agricultural and Mechanical College at Stillwater and at the university at Norman. The quality of the product was attested by these analyses and it was then readily sold. The amount of salt reported as made in the Territory in 1897 was 1,152 barrels, or a little over 320,000 pounds.

THE SALT INDUSTRY IN UTAH.

The following history of the salt-making industry in Utah was prepared by Mr. D. C. Adams, of Salt Lake City, for Mineral Resources, 1896, but was received too late for publication in that report.

The advent of the Mormons into the Territory of Utah was in 1847. The first salt was harvested by them from the shores of the Great Salt Lake in 1848. This salt was a natural product, the brine from the water being thrown back upon the shore by the westerly winds prevailing in the spring, forming small pools in low places. The warm, dry weather of July and August evaporated the water from the pools and deposited the salt, which was scraped up and used for domestic purposes and for curing meats. The early settlers were supplied with salt in this way until about 1860, when the idea was conceived of making dams which would hold large quantities of water in low places for evaporation. These dams were flooded in the spring, and the salt deposited during the summer by solar evaporation was gathered into piles along the banks and carried over from one year to another. About this time the chlorination process was discovered in the reduction of silver ores. About the first use of salt for this purpose was at the Alice mine, located at Butte, Montana. It was before the days of railroads, and the salt was packed on the backs of mules at a cost of about $200 per ton. As the chlorination process became better known other mills put in the system, including the Ontario, located at Park City, Utah. The salt for these works was hauled in wagons from the shores of the lake to Park City at a cost of $15 per ton. The rapidly increasing demand for salt caused further outlays in its production, and salt fields were made on high ground and the brine was pumped to them, the average height above the lake being about 20 feet. This was found to be greatly preferable to the plan of depending on the spring overflow into the low places, as the overflow was uncertain, while with pumps as much water could be raised as was desired. The increase in the demand was very rapid, especially for milling salt, and the output for all purposes reached a total of 50,000 tons in 1890, whereas in 1848 there was not over 500 to 1,000 pounds gathered. Several large companies have in the meanwhile been formed, to wit: The Intermountain Salt Company, the Inland Crystal Salt Company, the Deseret Salt Company, the People's Forwarding Company, and the Adams & Keisel Salt Company. Very little progress was made, however, in refining salt until some years later, when a new process was discovered, which is mentioned in connection with the methods of making salt.

Method of salt production.—About the month of March the pumps are started, the brine being pumped into large reservoirs. A reservoir contains from 10 to 20 acres. As the brine becomes stronger it is drawn off into other reservoirs or sloughs containing 3, 5, 8, 10, or 15 acres, as the case may be. These sloughs are made with a hard clay bottom and with a levee thrown up 3 or 4 feet high around the sides to retain the brine and which at the same time furnish a ditch on the outside to carry off fresh water. These sloughs are supplied from time to time during the summer, the reservoirs being kept stocked with brine until September or October, by which time anywhere from 3 to 6 inches of salt has been deposited. Harvesting then begins with wheelbarrows and tramway, the salt being stacked on the banks in large piles, shaped something like a hay stack, but not so high. A crust which answers every purpose of a shingle roof forms on each pile. This is the crude salt ready for market and is hauled to the mills for refining purposes or is shipped in this crude state to silver mills working under the chlorination process.

The latest improved machinery in the mills consists of revolving cylinders, roller buhrs, and a series of sieves. The salt is hauled from the piles to a crusher, whence it is carried by hoppers to the heated cylinders, which deliver the perfectly dried salt to the roller buhrs; thence it goes to the sieves. The salt is purified by means of a suction blower as it passes over the sieves. The impurities are lighter than the salt, and as it passes over the sieves the suction is set with just enough strength to take off the impurities and allow the salt to pass on to the bins, the different grains being carried to the proper bins by a series of hoppers. It is packed in 2, 3, 5, 10, 25, 50, 100, and 150 pound sacks. Utah salt is shipped east to Colorado, northwest to Puget Sound and Portland, and west to San Francisco. Of course the greatest profit is in salt sent to the intermediate points. Mr. Adams claims that, prices being equal at competitive points, Utah salt will take the preference. He attributes this mostly to the fact that the refined salt does not cake.

THE WORLD'S PRODUCTION OF SALT.[1]

The United States has for several years held second place in the list of salt-producing countries. Up to 1896 Great Britain held first place. The statistics of salt production in Great Britain in 1897 are not available at the time of writing this report. Her production in 1896 was 2,265,040 short tons, while that of the United States was 1,939,102 short tons. In 1897 the production in the United States increased to 2,236,248 short tons, about 30,000 tons less than the output of Great Britain in 1896, and 197,000 tons less than Great Britain's product in 1895. The salt production of the United States in 1896 was not quite 17 per cent of the total output of the principal producing countries. Our product in 1897 was nearly 20 per cent of the total in 1896.

Among the other producing countries Russia comes next to the United States, then Germany, India, and France, in order. None of the other countries averages as much as 5 per cent of the total. Austria-Hungary, whose product is less than 5 per cent of the world's total, furnishes nearly 50 per cent of the value. In this case the salt-producing industry is a government monopoly and one of its principal sources of revenue. The production of Austria-Hungary amounts to a little more than one-fourth of that of the United States, but the value of the product in that country is about four times that of the United States and was about five times that of Great Britain in 1894 and 1895. The first cost of salt to the consumer in the United States is about $2 per ton; in Austria-Hungary it is over $30 per ton. Under such conditions the small production is readily accounted for. Cheapness has increased the consumption of salt in the United States and developed many industries dependent upon it. The high prices charged for it by the Government of Austria-Hungary have restricted its production and consumption, and it is safe to assume that little salt is wasted by the people of that country.

The production of salt in Turkey is also a government monopoly and no statistics are published. The following table shows the production, in short tons, of salt by the principal countries of the world for such years as the figures are obtainable since 1890:

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[1] For sake of convenience the production of salt in all countries has been reduced in this paragraph to short tons.

The world's salt production.

Year.	United States.		Great Britain.		France. (*a*)	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1890	1,242,778	$4,752,286	2,403,462	$5,354,400	955,434	$3,458,174
1891	1,398,312	4,040,839	2,288,800	4,737,596	932,292	2,868,945
1892	1,637,845	5,654,915	2,191,307	4,177,795	1,100,898	3,318,366
1893	1,665,609	4,154,668	2,154,912	3,565,827	1,248,566	3,291,422
1894	1,815,438	4,739,285	2,504,221	3,703,601	1,001,498	2,762,216
1895	1,913,751	4,423,084	2,434,043	3,442,292	988,273	2,421,378
1896	1,939,102	4,040,839	2,265,040	3,233,073	1,178,038	2,492,402
1897	2,236,248	4,920,020	....	....	....	....

Year.	German Empire.		Italy.		Austria-Hungary. (*b*)	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1890	1,156,769	$3,750,642	524,552	$999,933	515,736	$17,863,887
1891	1,289,560	3,903,438	492,144	927,812	508,022	17,436,392
1892	1,286,365	3,968,650	461,733	857,692	490,390	16,069,952
1893	1,293,748	4,016,909	466,146	990,283	524,552	16,475,059
1894	1,386,316	4,143,710	477,166	912,118	565,326	17,256,516
1895	1,347,014	4,131,945	526,370	1,030,350	530,062	17,075,675
1896	1,436,258	4,204,910	497,915	935,466	(*c*)	(*c*)
1897	....	....	....	....	....	....

Year.	Russia.		Spain.		India.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1890	1,531,736	$2,613,611	678,531	$1,750,444	1,159,395	$1,948,104
1891	1,489,008	4,978,589	642,292	1,687,300	1,139,468	1,690,294
1892	1,608,595	4,627,700	750,059	2,505,855	1,008,330	1,750,317
1893	1,489,687	4,281,970	166,913	82,076	940,547	1,546,597
1894	1,493,572	3,317,160	227,645	85,786	1,452,654	2,538,121
1895	1,705,896	3,887,090	359,604	918,775	1,282,522	2,058,678
1896	(*c*)	(*c*)	574,970	1,113,494	1,131,472	1,753,371
1897	....	....	....	....	....	....

a Includes product of Algeria.
b Government monopoly.
c Latest figures available are used in making up the total.

The world's salt production—Continued.

Year.	Canada.		Other countries.		The world.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1890........	43, 754	$198, 857	....	....	10, 212, 147	$42, 690, 338
1891........	45, 021	161, 179	....	....	10, 224, 919	42, 432, 384
1892........	45, 486	162, 041	....	....	10, 581, 013	43, 093, 283
1893........	62, 324	195, 926	....	....	10, 013, 004	38, 600, 737
1894........	57, 199	170, 687	*a* 2, 772	$9, 515	10, 983, 807	39, 638, 715
1895........	52, 376	160, 455	*b* 159, 129	1, 155, 738	11, 299, 040	40, 605, 460
1896........	43, 960	169, 693	*c* 128, 959	408, 111	11, 291, 672	39, 214, 124
1897........	....	*d* 190, 000	....	....	....	....

[a] Cape Colony and Ceylon.

[b] Cape Colony, Ceylon, Greece, Bosnia, and Herzegovina.

[c] Cape Colony, Greece, Bosnia, and Herzegovina.

[d] Partly estimated.

FLUORSPAR.

By Edward W. Parker.

PRODUCTION.

The production of fluorspar in the United States during 1897 amounted to 5,062 short tons, valued at $37,159, compared with an output of 6,500 tons in 1896, worth $52,000, indicating a decrease in amount of 1,438 tons and a falling off of $14,841 in the value. Of the product in 1897, about 2,500 tons were from Hardin County, Illinois, the remainder being obtained from Crittenden County, Kentucky. In addition to the Kentucky deposits, from which the product in 1896 and 1897 was obtained, another vein in the same county was being developed at the close of the year and during the early part of 1898. This vein is said to yield a clear white variety of fluorspar. The company owning the deposit has signified its intention to erect one or two mills for grinding the spar and preparing it for market. This equipment will, it is stated, enable the company to largely increase its production.

It will be observed that the value of the product in 1897 shows a decline in the price. This was rather to be expected, for the price in 1896 ($8 per ton) was unusually high—higher, in fact, than at any previous time in the history of fluorspar mining. Prior to 1896 the highest price reported was in 1891, when it was $7.80. The average price in 1897 was $7.34 per ton, which was higher than in any previous year, with the two exceptions of 1891 and 1896.

The fluorspar produced in the United States is used in the manufacture of hydrofluoric acid and opalescent glass. It is also valuable as a flux in iron smelting. Fluorspar or fluoride of calcium is one of the rare occurrences of fluoride compounds in nature. It is found commercially in the United States only in the two localities noted. Cryolite, a fluoride of sodium and aluminum, is another of these rare compounds. Its occurrence has been observed at the base of Pikes Peak, in Colorado, but no attempt has been made to mine it.

The following table shows the annual production of fluorspar since 1882:

Production of fluorspar in the United States from 1882 to 1897.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1882..........	4,000	$20,000	1890..........	8,250	$55,328
1883..........	4,000	20,000	1891..........	10,044	78,330
1884..........	4,000	20,000	1892..........	12,250	89,000
1885..........	5,000	22,500	1893..........	12,400	84,000
1886..........	5,000	22,000	1894..........	7,500	47,500
1887..........	5,000	20,000	1895..........	4,000	24,000
1888..........	6,000	30,000	1896..........	6,500	52,000
1889..........	9,500	45,835	1897..........	5,062	37,159

IMPORTS OF CRYOLITE.

The records of the Bureau of Statistics of the Treasury Department do not make any separation of fluorspar imported into the United States; it is included among minerals and ores "not elsewhere specified." Cryolite, however, is imported from Greenland by the Pennsylvania Salt Company, for use in the manufacture of sodium and alum salts.

The imports of cryolite for a series of years are shown in the following table:

Imports of cryolite from 1871 to 1897.

Year ended—	Amount.	Value.	Year ended—	Amount.	Value.
	Long tons.			*Long tons.*	
June 30, 1871..	....	$71,058	Dec. 31, 1885..	8,275	$110,750
1872..	....	75,195	1886..	8,230	110,152
1873..	....	84,226	1887..	10,328	138,068
1874..	....	28,118	1888..	7,388	98,830
1875..	....	70,472	1889..	8,603	115,158
1876..	....	103,530	1890..	7,129	95,405
1877..	....	126,692	1891..	8,298	76,350
1878..	....	105,884	1892..	7,241	96,932
1879..	....	66,042	1893..	9,574	126,688
1880..	....	91,366	1894..	10,684	142,494
1881..	....	103,529	1895..	9,425	125,368
1882..	3,758	51,589	1896..	3,009	40,056
1883..	6,508	97,400	1897..	10,115	135,114
1884..	7,390	106,029			

THE CRYOLITE OF GREENLAND.[1]

In 1850 the Danish Government held, in Copenhagen, an exhibition of Eskimo tools and products from their distant colony in Greenland. Among the implements shown were a number of stone sinkers, which the natives had used for their nets, some of which sinkers were made from a white, translucent mineral. Dr. Hartman, a scientist, noticed these, and having secured a specimen, analyzed it and found it to be the rare and valuable mineral cryolite.

During the following year the Danish Government made investigations, and discovered a large deposit near Ivigtuk, on the west coast of Greenland, in latitude 61° 13′. Strangely enough, the Eskimos had chosen the ground above the deposit for a fishing village, and the fact that they used blocks of cryolite for the foundations of their tents probably led to its discovery. Fourteen years later Dr. Julius Thompson commenced mining, and the industry has steadily grown in importance ever since.

In the early days of the cryolite industry the greater part of the output was used for the production of aluminum. Bauxite soon supplanted it in that line, and then it was found that from no other material could alum and sodium carbonate be made so cheaply and so pure. The Pennsylvania salt company accordingly contracted for the whole output for that purpose, and mining on a large scale began. About this time some experiments were made with cryolite, in the endeavor to make from it a transparent glass. They failed, but a beautiful opaque porcelain-like substance was the result; far cheaper than and as beautiful as china. By merely melting a mixture of cryolite, sand, and zinc oxide this material is formed, and ware of any desired shape can be stamped from it. It is so tough, that cups and plates made from it can be thrown down violently without breaking.

Very lately cryolite has been used once more in the manufacture of aluminum. By means of a powerful current it is melted, and the corundum, Al_2O_3, which forms the source of the metal, is dissolved and decomposed within it.

It can be easily seen how great an economic value cryolite possesses and of what importance it is in the arts; and as the Greenland deposit is the only one in the world, at which it occurs in workable quantities, the Ivigtuk mines have naturally become of great importance.

Arlssuk Fiord, which leads from the ocean to the mines, is a narrow strait between snow-covered granite mountains. The inland ice reaches almost to it, and bergs and pack ice close it to navigation for nine months of the year. It is so deep that vessels in the harbor can fasten their bows to the rocky walls and get no soundings from the stern.

The cryolite occurs in a great vein of arey gneiss, penetrating the granite. The form of the deposit is rather peculiar. It is neither a dike nor a stratum, but seems to be an immense bed, possibly great veins, penetrating the gneiss at an angle of about 45°, and extending far below sea level. The deposit consists of two parts. First, an inner bed or vein, about 500 by 1,000 feet in section, containing nearly pure cryolite. It is from this vein that most of the cryolite is obtained. Whole shiploads have been taken out at a depth of about 100 feet, averaging 99½ per cent of the pure mineral. The cryolite of this vein was reported, before the mine had been much worked, to be white only for 10 or 15 feet from the surface, and many theories were presented to account for the fact, one of which claimed that two intruding dikes, on either side of the vein, had by their heat bleached out the cryolite between. The labor was in vain, for the pit has now been sunk more than 100 feet, and the cryolite grows whiter and purer as the mines increase in depth.

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[1] H. S. Canby, in the Yale Scientific Monthly.

The limits of this vein are generally very sharply defined. Surrounding it is another peripheral bed, which gradually merges into the gneiss. The cryolite here is not nearly so pure as that of the central portion, and with it occur the most important ores and minerals of the mine, as well as the various compounds resulting from the alteration of the cryolite.

Between these two veins there is sometimes an intermediate portion, in which the cryolite seems to act as a matrix to the minerals of the outer zone, instead of forming the mass.

The mines are all open workings and have been carried far below the water line. If the pits should be left unprotected during the long winters the water and snow would soon fill them, and by spring there would be thousands of tons of ice to remove. This difficulty is overcome in a simple but ingenious manner. At the end of the working season the mines are flooded, and the little lake thus formed freezes over and ice is formed of a thickness never exceeding 5 feet. When warm weather comes again, it is only necessary to pump out the pits, clear away the little ice which remains, and start to work again.

The product of the mines, amounting to many thousands of tons a year, is all shipped to the contractors by means of a small fleet, which plies between Philadelphia and Ivigtuk. Even in the middle of summer the ocean near the Greenland shores is full of icebergs, and navigation is difficult and dangerous. It happens every few years that some unfortunate vessel, delayed by adverse winds at Ivigtuk, is caught in the pack ice and forced either to return to the mines or winter in the ice.

As a mineral, cryolite is notable as being one of the few fluorine compounds found in nature. It is a fluoride of sodium and alminum, with the formula $AlF_3 + 3NaF$; specific gravity of 2.95-96, and hardness of 2.5 in Dana's scale. It crystallizes in the monoclinic system. the crystals generally simple, but sometimes very complicated. The pure mineral is subtranslucent and has a peculiar property of increasing in transparency when wet. At Ivigtuk the crystals are found in cavities within the mass. They are usually small, and well-formed specimens are very rare. Cryolite has been found at only three places: Ivigtuk, the Urals, and at the base of Pike's Peak, in Colorado.

The inner bed of the Greenland mine contains several very interesting minerals which have resulted directly from the alteration of the cryolite. Of these, the commonest and most important is pachnolite, a fluoride in which some of the sodium of cryolite has been replaced by calcium.

MICA.

By Edward W. Parker.

PRODUCTION.

The amount of sheet mica produced in the United States in 1897 exceeded that of any year since 1885, aggregating 82,676 pounds. To this should be added 740 tons of scrap mica ground for manufacture into lubricants, wall papers, boiler covering, etc. The value of the sheet mica produced in 1897 was $80,774, and the scrap mica was valued at $14,452, a total of $95,226. This was more than in any year since 1892.

The following table shows the annual production of mica in the United States since 1880:

Production of mica since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1880	81,669	$127,825	1890	60,000	$75,000
1881	100,000	250,000	1891	75,000	100,000
1882	100,000	250,000	1892	75,000	100,000
1883	114,000	285,000	1893	....	88,929
1884	147,410	368,525	1894	....	52,388
1885	92,000	161,000	1895	....	55,831
1886	40,000	70,000	1896.. Sheet	....	65,441
1887	70,000	142,250	Scrap	....	1,750
1888	48,000	70,000	1897.. Sheet	82,676	80,774
1889	49,500	50,000	Scrap	a740	14,452

a Tons.

The States from which the product in 1897 was obtained were Idaho, New Hampshire, North Carolina, South Dakota, and Wyoming, the output from the last mentioned amounting, however, to only 12 pounds. North Carolina contributed about 80 per cent of the sheet-mica product, with an output of 65,225 pounds out of a total of 82,676 pounds. In the production of scrap mica North Carolina is credited with 607 short tons, while New Hampshire yielded the remainder, 133 short tons.

IMPORTS.

The following table shows the imports of unmanufactured mica from 1869 to 1896:

Unmanufactured mica imported and entered for consumption in the United States, 1869 to 1896, inclusive.

Year ended—	Value.	Year ended—	Value.
June 30, 1869	$1,165	June 30, 1883	$9,884
1870	226	1884	28,284
1871	1,460	1885	28,685
1872	1,002	Dec. 31, 1886	a 56,354
1873	498	1887	a 49,085
1874	1,204	1888	a 57,541
1875	....	1889	a 97,351
1876	569	1890	a 207,375
1877	13,085	1891	95,242
1878	7,930	1892	218,938
1879	9,274	1893	147,927
1880	12,562	1894	126,184
1881	5,839	1895	174,886
1882	5.175	1896	169,085

a Including mica waste.

Under the new classification, made necessary by the Dingley tariff bill in effect from and after July 24, 1897, mica is designated as "unmanufactured" and "cut or trimmed." A specific import duty of 6 cents per pound is imposed upon the former, and 12 cents per pound upon the latter, with an additional 20 per cent ad valorem duty upon each. The imports during 1897, before and after the new classification took effect, were as follows:

Mica imported and entered for consumption in 1897.

		Pounds.	Value.
Prior to July 24		656,118	$140,353
After July 24	Unmanufactured	66,821	10,981
	Cut or trimmed	226,771	41,068
Total		949,710	192,402

REVIEW OF THE INDUSTRY.

Prior to 1895 the reports of the custom-houses to the Bureau of Statistics of the Treasury Department made no statement of the amounts of mica imported into the United States. Such duties as were imposed were of an ad valorem character, and the returns of the custom-houses give only the value of the imports. Comparisons with previous years, therefore, must be based entirely upon the value. From this it will be seen that the imports in 1897 exceeded those of any previous year, with the exceptions of 1890 and 1892. It will be further noted that 73 per cent of the imports in 1897 were made before the new tariff law took effect, in July.

Considering the value of the domestic product with that of the imported material as a basis for the domestic consumption, the total for 1897 reaches a value of $287,628. The only year when this was exceeded since the importations of India mica began, in 1884, was in 1892, when the imports were valued at $218,938 and the domestic product at $100,000.

While the domestic product in 1897 was larger than for several years, it was not much more than 25 per cent of the value of the mica produced in the United States in 1884. The importation of India mica began in 1884, and its effect upon the domestic production was immediately apparent. Mica was on the free list prior to 1891, and the inability of our mines to compete with it is shown in the decrease from $368,525, the value of the domestic product in 1884, to $161,000 in 1895. In the fifteen years preceding 1884 the value of imported mica had not exceeded $14,000 in any one year, and the average for the period was only $4,658 per annum. In 1884 and 1885 the value of the importations was not large, being something over $28,000 in each year. This was, however, for rough mica, and no estimate can be made as to the value of the cut mica obtained from it. The same may be said of the years succeeding 1885. The demoralization of the mica-mining industry in the United States since 1884 is the best indication that the value of the imported mica has not been overstated. In the five years 1880 to 1884, inclusive, the value of our domestic product averaged $256,000 annually. In the next twelve years, ending with 1896, the average annual value of the product was $86,000. During the same period the imports averaged nearly $120,000. That is to say, the average value of the domestic product in the two periods shows a decline of 66⅔ per cent, while the value of the imports in the second period was more than 25 times that of the first. The average value of the domestic product in the first period was more than 50 times that of the imported. In the second period the value of the imported mica has been nearly 1½ times that of the domestic, and, as stated before, the values given for the imported product, particularly during the years 1891 to July, 1897, when an ad valorem duty was imposed, have not been excessive. The value of the domestic product in 1897 was about one-half that of the imported.

The following table is interesting as showing the sources from which the mica imported into the United States during the last three years has been obtained. The periods are fiscal years, ending June 30.

Imports of mica into the United States and countries from which exported.

Countries from which exported.	1895.		1896.		1897.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
United Kingdom	110,850	$34,181	139,858	$57,877	205,112	$89,506
Canada	546,905	39,637	620,282	57,908	416,306	54,620
East Indies.....	148,056	48,731	492,681	95,595	255,877	42,469
Other countries.	15,171	4,966	11,245	3,617	4,215	1,250
Total.....	820,982	127,515	1,264,066	214,997	881,510	187,845

CANADIAN PRODUCTION.

The geological survey of Canada gives the following statement of the value of the mica produced in the Dominion since 1886. To this the value of the imports from Canada into the United States during the last three years has been added, to indicate what proportion of the product finds its market in this country:

Production of mica in Canada since 1886.

Calendar year.	Value.	Value Canada mica imported into the United States.
		Fiscal years.
1886.................	$29,008	....
1887.................	29,816	....
1888.................	30,207	....
1889.................	28,718	....
1890.................	68,074	....
1891.................	71,510	....
1892.................	104,745	....
1893.................	75,719	....
1894.................	45,581	....
1895.................	65,000	$39,637
1896.................	60,000	57,908
1897.................	75,000	54,620

EXPORTS OF MICA FROM INDIA.

The following table has been compiled from the official government report on "The Review of Mineral Production in India." The report states that the total production in 1896 was 309.2 long tons, against 375.9 tons in 1895, and 180 tons in 1894. In considering the statement of exports it is worth while to note that in the six years given, the total amount of mica exported to the United States was 1,708,672 pounds, while the exports to Great Britain were 1,630,496 pounds. The total exports during the period were 3,466,064 pounds, showing that practically 50 per cent of the entire output was shipped to the United States. The United States, in fact, consumes much more than 50 per cent of the mica product of India. Probably one-half of the mica exported from India to Great Britain finds its ultimate market in the United States. This is evinced by the table on the preceding page, showing that in the last three fiscal years the United States has imported from Great Britain an average of nearly 150,000 pounds annually. As the British reports do not mention a production of mica in the United Kingdom, it is safe to assume that the imports of mica reported by the Treasury Department as received from Great Britain consist of a reexported India product. According to the preceding table the average annual imports of mica from India direct amounted to 298,871 pounds. The following table shows that the average exports from India to the United States in six years amounted to 284,779 pounds, and in the latter three years of this period to 338,763 pounds. If we add the mica imported as from Great Britain to that imported directly from India, the United States has taken a total of 1,342,434 pounds of India mica in the three years ending June 30, 1897, an average of 447,478 pounds per year. During the same period the amount of mica imported from Canada has averaged about 530,000 pounds per year.

Exports of mica from India, 1891 to 1896.

Year.	To United Kingdom.	To United States.	To other countries.	Total.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1891	363,776	330,064	21,168	715,008
1892	91,728	156,912	11,760	260,400
1893	155,456	205,408	11,984	372,848
1894	290,976	230,832	21,840	543,648
1895	340,368	216,944	18,592	575,904
1896	388,192	568,512	41,552	998,256

ASBESTOS.

By EDWARD W. PARKER.

PRODUCTION.

The commercial product of asbestos in 1897 was limited to two localities—Sall Mountain, Georgia, and Elsinore, California. In amount the product in 1897 was 580 short tons, exceeding that of 1896 by 15 per cent, while the value increased from $6,100 to $6,450, a little more than 5 per cent. The domestic product is entirely true asbestos, which usually occurs associated with soapstone, and is in fact a fibrous variety of hornblende. Mineralogically it is entirely distinct from the Canadian product, which is a fibrous form of serpentine, and which should properly be classed as chrysotile. Both minerals, however, are similar in their heat-resisting properties, and both are usually classed commercially as asbestos. Manufacturers of asbestos textiles in the United States obtain their supply of crude material almost exclusively from the Canadian deposits of chrysotile at Black Lake and Thetford, as is shown by the reports of the Bureau of Statistics of the Treasury Department. The total value of the asbestos imports for the fiscal year ending June 30, 1897, was $191,097, of which the imports from Canada were worth $190,971, the difference ($126) being made up by two small shipments from Germany.

Canadian asbestos, or chrysotile, possesses greater strength and elasticity of fiber than the domestic product, and is consequently much preferred for the manufacture of woven fabrics. Occurrences of chrysotile similar to that of the Canadian product have been noted in the United States in Loudoun County, Virginia, and near Casper, Wyoming, but conditions have not been favorable to their successful development, and, except for specimens and the necessary assessment work to maintain title, they have not been exploited. Fibrous hornblende, or true asbestos, which is produced commercially in the United States, is not so well adapted for the manufacture of textiles as the Canadian chrysotile, owing to the brittleness of fiber, but for such purposes as fireproofing, paints, boiler and safe packing, etc., where strength of fiber is not essential, its heat-resisting qualities make it valuable. The use of the domestic product is, therefore, confined to these lines.

Workable deposits of asbestos have been found in several States, notably in California, Georgia, Maryland, Montana, Oregon, South Dakota, and Washington. Most of these have been worked at one time or another, but with the exception of the Sall Mountain, Georgia, mines, which began producing in 1894, the production has amounted to very little in the last ten years. In Mineral Resources for 1882 and for 1883–84 the production was reported at from 1,000 to 1,200 tons, principally from California, but fell off to 300 tons in 1885, 200 tons in 1886, and 150 tons in 1887, after which time it did not exceed 100 tons in any year except 1892 (104 tons) until 1894, when the Sall Mountain mines were opened. The richness and proximity of the Canadian chrysotile deposits, added to the superior quality of the fiber, have been potential factors against the successful operations of our eastern deposits, while the long distance from the manufacturing centers, and the consequent expensive freight costs, have militated against the development of the western localities.

The following table exhibits the annual production of asbestos in the United States since 1880, with the value:

Annual production of asbestos since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	150	$4,312	1889	30	$1,800
1881	200	7,000	1890	71	4,560
1882	1,200	36,000	1891	66	3,960
1883	1,000	30,000	1892	104	6,416
1884	1,000	30,000	1893	50	2,500
1885	300	9,000	1894	325	4,463
1886	200	6,000	1895	795	13,525
1887	150	4,500	1896	504	6,100
1888	100	3,000	1897	580	6,450

Comparing the above table with that of the table of imports, which is given below, it will be seen that there is a profitable market to be supplied with domestic fiber if any be found which is equal in quality to that of the Canadian chrysotile, nearly all of the imports into the United States being from the Canadian mines.

IMPORTS.

The following table shows the value of asbestos imported since 1869:

Value of asbestos imported since 1869.

Year ended—	Unmanufactured.	Manufactured.	Total.
June 30, 1869		$310	$310
1870		7	7
1871		12	12
1872			
1873	$18		18
1874	152		152
1875	4,706	1,077	5,783
1876	5,485	396	5,881
1877	1,671	1,550	3,221
1878	3,536	372	3,908
1879	3,204	4,624	7,828
1880	9,736		9,736
1881	27,717	69	27,786
1882	15,235	504	15,739
1883	24,369	243	24,612
1884	48,755	1,185	49,940
Dec. 31, 1885	73,026	617	73,643
1886	134,193	932	135,125
1887	140,264	581	140,845
1888	168,584	8,126	176,710
1889	254,239	9,154	263,393
1890	252,557	5,342	257,899
1891	353,589	4,872	358,461
1892	262,433	7,209	269,642
1893	175,602	9,403	185,005
1894	240,029	15,989	256,018
1895	225,147	19,731	244,878
1896	229,084	5,773	234,857
1897	263,640	4,624	268,264

CANADIAN PRODUCTION.

As the supply of asbestos for the United States is drawn almost entirely from Canada, the following table of production for that country will be found of interest:

Annual product of asbestos in Canada since 1879.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Tons.			*Tons.*	
1879	300	$19,500	1889	6,113	$426,554
1880	380	24,700	1890	9,860	1,260,240
1881	540	35,100	1891	9,279	999,978
1882	810	52,650	1892	6,042	388,462
1883	955	68,750	1893	6,473	313,806
1884	1,141	75,079	1894	7,630	420,825
1885	2,440	142,441	1895	8,756	368,175
1886	3,458	206,251	1896	12,250	429,856
1887	4,619	226,976	1897	a25,262	324,700
1888	4,404	255,007			

a Including asbestic.

The deposits, production, and methods of mining and manufacture of Canadian asbestos or chrysotile have been liberally treated in preceding volumes of Mineral Resources, and there is not much to add to what has already been written except to record the development of a new industry associated intimately with asbestos mining. The new industry is the manufacture of "asbestic," a fireproof wall plaster made from the serpentine rock with which the chrysotile occurs in one mine at Danville, Quebec, and which is itself almost entirely fibrous in character. The rock, when crushed and without the mixture of any foreign material except a small percentage of lime, forms a cement or plaster which is said not only to be perfectly fireproof, but to effectually resist the action of acids and gas fumes. For the latter reason it is especially adapted as a protective covering for iron and steel structures subjected to the action of gases (particularly sulphur) contained in smoke, such as bridges under which or through which locomotives are continually passing. It is claimed that asbestic plaster is of light weight, and can be applied as well to light structures and thin partitions as to heavy structures and thick walls.

GRAPHITE.

PRODUCTION.

The production of graphite in the United States during 1897 amounted to 1,254,402 pounds of crystalline and refined plumbago and 1,108 short tons of amorphous graphite and graphitic coal. The crystalline product was obtained chiefly from the mines at Ticonderoga, New York (the amount shipped from there in 1897 being more than double the shipments in 1896), from Byers, Chester County, Pennsylvania, and from near Providence, Rhode Island. Amorphous graphite was mined in the two latter States and in Baraga County, Michigan. Graphitic coal is mined only at Valley Falls, Rhode Island. Compared with 1896, the production of crystalline graphite increased a little more than 130 per cent, while the other grades increased about 46 per cent. The aggregate value increased only 12 per cent.

The Rhode Island product is used in the manufacture of crucibles, paints, roofing material, etc.; the Michigan output is used almost exclusively for making graphite paint, while the Ticonderoga graphite goes into the manufacture of crayons, lead pencils, crucibles, lubricants, paints, and all other purposes for which graphite is used. The following table shows the annual production of graphite since 1880:

Production of graphite since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1880..pounds.	622,500	$49,800	1891..pounds..	1,559,674	$110,000
1881.... do...	400,000	30,000	1892.... do....	1,398,365	87,902
1882.... do...	425,000	34,000	1893.... do....	843,103	63,232
1883.... do...	575,000	46,000	1894.... do....	918,000	64,010
1884.... do...	500,000	35,000	1895 ... do....	644,700	52,582
1885.... do...	327,883	26,231	short tons	2,793	
1886.... do...	415,525	33,242	1896 pounds...	535,858	48,460
1887.... do...	416,000	34,000	short tons	760	
1888.... do...	400,000	33,000	1897 pounds...	1,254,402	54,277
1889....................		72,662	short tons	1,108	
1890....................		77,500			

NEW DEVELOPMENTS.

Two companies were formed in 1897 to exploit graphite deposits in two Southern States—North Carolina and Texas. The North Carolina deposits are in McDowell County, along the eastern slope of the Blue Ridge Mountains. Maj. George D. Miles, of Black Mountain, and others have organized the American Graphite Company for the purpose of mining and refining the graphite, which is said to exist in large quantities and to be favorably situated. The deposit is in the southwest corner of McDowell County, and is traceable for 5 miles in a northwesterly direction. It is about 5 miles from the western North Carolina division of the Southern Railway, the grade of the country road to the railroad being in favor of the loaded teams.

The Texas deposits are in Llano County. The Texas Graphite and Asbestos Company, with headquarters at Houston, was formed in 1897 for the purpose of developing the graphite, and also asbestos and soapstone deposits, which occur in the same locality. The graphite occurs in two places about 12 miles apart in a northeasterly-southwesterly direction. The one to the north is on the north side of the Llano River and on the line of the Austin and Northwestern Railroad. This deposit is said to yield a flake graphite similar to the Ceylon product. The other deposit is about 8 miles due south from the town of Llano and is said to contain granular graphite of excellent quality. The company intends to establish its refining works at Houston, where exceptional facilities for railroad and water shipment are afforded.

IMPORTS.

As will be seen in the following table, when compared with the imports the value of the domestic product is small, though there was a considerable decline in the imports in 1894 and 1895. The imports of 1896 exceeded those of 1894 and 1895 combined. From 1890 to 1893 the amount of graphite imported ranged from 212,360 hundredweight in 1891 to 288,740 hundredweight in 1893, the average for four years being 247,649 hundredweight, or 12,382 tons, the average value being $670,745. The average value per pound for the four years was 2.7 cents. In 1894 the imports amounted to 5,814 long tons, equivalent to 13,023,360 pounds, valued at $225,720, or about 1.7 cents per pound. In 1895 the imports were 8,814 long tons, or 19,743,360 pounds, worth $260,090, or about 1.3 cents per pound. The imports in 1896 were 15,230 long tons, or 34,115,200 pounds, valued at $437,159, or about the same per pound as the previous year. It is to be noted that while the imports of graphite in 1896 were the largest on record, being nearly 73 per cent more than in 1895, the domestic product, particularly in value, was the smallest in a number of years. Conversely, the imports in 1897 decreased to an amount slightly less than in 1895 (although the value was $10,862 more), and the domestic product of crystalline graphite increased 130 per cent.

Graphite imported into the United States since 1867.

Year ended—	Unmanufactured.		Manufactured.	Total.
	Quantity.	Value.		
	Cwt.			
June 30, 1867	27, 113	$54, 131	....	$54, 131
1868	68, 620	149, 083	....	149, 083
1869	74, 846	351, 004	....	351, 004
1870	80, 795	269, 291	$833	270, 124
1871	51, 628	136, 200	3, 754	139, 954
1872	96, 381	329, 030	....	329, 030
1873	157, 539	548, 613	....	548, 613
1874	111, 992	382, 591	....	382, 591
1875	46, 492	122, 050	....	122, 050
1876	50, 589	150, 709	17, 605	168, 314
1877	75, 361	204, 630	18, 091	222, 721
1878	60, 244	154, 757	16, 909	171, 666
1879	65, 662	164, 013	24, 637	188, 650
1880	109, 908	278, 022	22, 941	300, 963
1881	150, 927	381, 966	31, 674	413, 640
1882	150, 421	363, 835	25, 536	389, 371
1883	154, 893	361, 949	21, 721	383, 670
1884	144, 086	286, 393	1, 863	288. 256
1885	110, 462	207, 228	....	207, 228
1886	83, 368	164, 111	....	164, 111
1887	168, 841	331, 621	....	331, 621
Dec. 31, 1888	184, 013	353, 990	....	353, 990
1889	177, 381	378, 057	....	378, 057
1890	255, 955	594, 746	....	594, 746
1891	212, 360	555, 080	....	555, 080
1892	233, 540	667, 775	....	667, 775
1893	288, 740	865, 379	....	865, 379
1894	*a* 5, 814	225, 720	....	225, 720
1895	8, 814	260, 090	....	260, 090
1896	15, 230	437, 159	....	437, 159
1897	8, 533	270, 952	....	270, 952

a Long tons since 1894.

CANADIAN GRAPHITE.

The Geological Survey of Canada in its report for 1896 gives the productions of graphite in Canada for a series of years. From the figures of production for 1896 and past years, given in the table below, it will be seen that the graphite industry of Canada can hardly be said to be well established, both the amounts and value per ton showing great variations.

Annual production of graphite in Canada since 1886.

Calendar year.	Tons.	Value.
1886	500	$4,000
1887	300	2,400
1888	150	1,200
1889	242	3,160
1890	175	5,200
1891	260	1,560
1892	167	3,763
1893	None.	None.
1894 (*a*)	69	223
1895	220	6,150
1896	139	9,455

a Exports.

The average value per ton for the first three years given in the table is about $8. After that a considerable rise is evident. The reason for this is to be found in the fact that in 1889 the Quebec mines began to contribute to the total, while previously the only production had been that of low-grade mineral in New Brunswick. The Quebec product, being in general more highly prepared, brought an average price per ton varying from $60 to $80, thus raising the average value of the whole product.

PRODUCTION IN OTHER COUNTRIES.

The principal foreign producers of graphite of which the statistics are obtainable are Germany, Italy, Austria-Hungary, and the island of Ceylon. The production from these countries for four years has been as follows:

Production of graphite in other countries, in metric tons.

Country.	1893.	1894.	1895.	1896.
Germany	....	3,133	3,751	5,248
Italy	1,465	1,575	2,657	3,148
Austria-Hungary	23,806	24,121	28,443	....
Ceylon	....	10,718	13,711	10,463

In addition to the above the following countries contribute a comparatively small amount: Russia produced 164 metric tons in 1891, 82 tons in 1892, and 311 tons in 1894; Japan reported a product of 4,500 metric tons in 1890, but only 46 tons in 1893, and none since 1893; India produced 1,623 tons in 1894, France 13 tons in 1895, and Great Britain 41 tons the same year. The principal sources from which our imports are received are given in the reports of the Bureau of Statistics of the Treasury Department. During the fiscal year ending June 30, 1897, we received from British East Indies (including Ceylon) 10,592 long tons, nearly 90 per cent of the total imports. Germany exported 45 long tons to this country, Italy 153 long tons, and Canada 270 long tons, while 912 tons were received from Mexico.

MINERAL PAINTS.

By Edward W. Parker.

MINERALS USED AS PIGMENTS.

The mineral substances included under this heading are those which are mined and prepared primarily as pigments. They consist of iron ores (usually hematites) which are ground and used in the manufacture of red and brown pigments, and which are not included in the production of iron ores for iron making; clay and other earths containing iron, used in making yellow and brown pigments, such as ocher, umber, sienna, etc.; barytes (barium sulphate) or "heavy spar," used as a substitute for or an adulterant of white lead; slate, or shale; soapstone; asbestos; graphite, and a pure form of gypsum producing terra alba. All of these pigments are made directly from the crude minerals and may be considered natural pigments. It is not always possible, however, to segregate the amount of soapstone, asbestos, and graphite which goes into paint, and reports of the mineral paint product are therefore partially included in the papers relating to those materials. Venetian red, obtained from iron sulphate by roasting, is also included among the mineral paints, as the amount of iron so consumed is so small when compared with the iron product that it would not affect the total. Zinc white is produced directly from the ores, and properly belongs in the product of pigments.

To the above should be added the preparations made from pig lead, namely, white lead, red lead, litharge, and orange mineral; also vermilion, made from quicksilver; chrome yellow, made from potassium bichromate; blanc fixe, made by treating barium carbonate with sulphuric acid and precipitating artificial barytes. The bases from which these pigments are obtained are included in the production of pig lead, quicksilver, chromium, etc., and the pigments themselves, being the results of chemical decomposition and combination, are not grouped among the "mineral paints," although the statistics are treated in this chapter. It has also been customary to treat barytes separately. This custom is adhered to in this report.

PRODUCTION.

As shown in the following table, the pigments classed among mineral paints, and whose production is not included elsewhere, are ocher, umber, sienna, metallic paint (iron ore), slate, soapstone, venetian red, and zinc white. The production in 1897 also includes 2,000 tons of graphitic shale shipped from Cartersville, Georgia, which was used for the purpose of coloring fertilizers.

The amount of mineral pigments produced in the United States in 1897 exceeded that of any previous year in our history, though the value of the product in 1897 was less than that of 1892—the greater value in that year being due principally to a larger reported production and value for zinc white. The production of all kinds of mineral pigments increased from 68,032 tons in 1896 to 85,913 tons in 1897, a differerence of 17,881 short tons, or about 26 per cent. The value increased $592,838—from $1,952,955 to $2,545,793—a gain of 30 per cent, the comparative gain in value being due to an increase of 5,000 tons in the production of zinc white. Except for this increase of zinc-white production, there would have been a comparative decline in value, due to the inclusion in the production for 1897 of 2,000 tons of graphitic shale, used, as previously stated, for coloring fertilizers, and which was valued at only $3 per ton. This product has not been reported previously. Its low price, $3 per ton, is less than one-third that of mortar color, which is the lowest-priced pigment heretofore considered.

The statistics of ocher production in 1897 show a somewhat better condition than existed in 1896. The quantity of the output in 1897 (14,006 short tons) was not materially different from that of the preceding year, when it was 14,074 short tons. The value, however, increased from $136,458 in 1896 to $162,764 in 1897, a gain of $26,306, or nearly 20 per cent. The average price for ocher in 1896 was unusually low, having declined to $9.70 per ton as compared with $11.50 in 1895, $9.92 in 1894, and $12.30 in 1893. In 1897 the average price was $11.62 per ton, the highest since 1893, and nearly $2 per ton more than in 1896.

There was an increased production of metallic paint in 1897, the amount being 1,894 tons more than in 1896, but the steady decline in values since 1893, noted in the preceding volume, not only continued in 1897, but was more pronounced than in any year since 1894. The average price per ton realized in 1897 was $11.24, 93 cents less than in 1896, $1.05 less than in 1895, and $1.23 less than in 1894. The production of mortar colors decreased 1,423 short tons—from 9,660 tons in 1896 to 8,237 tons in 1897. The price per ton declined from $9.28 to $9.17.

The production of venetian reds in 1897 more than trebled that of 1896, and was nearly treble that of 1895. In the face of such an increased output the decrease in the price per ton from $22.68 in 1896 to $21.67 in 1897 is remarkable only for being so slight.

Zinc-white production increased from 20,000 short tons in 1896 to 25,000 short tons in 1897, with a proportionate increase in value.

The production of umber and sienna both showed considerable increases in 1897. The output of the former was 480 tons against 165 tons in 1896, while the value per ton advanced from $16.04 to $16.89. The production of sienna increased from 395 to 620 tons, while the value per ton increased from $13.71 to $17.11. Slate ground for pigment amounted in 1896 to 4,795 tons, and in 1897 4,666 tons, the value per ton increasing from $9.35 to $10.

The production of mineral paints for the last five years has been as follows:

Production of mineral paints since 1893.

Kind.	1893.		1894.		1895.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
Ocher	10,517	$129,393	9,768	$96,935	12,045	$139,328
Umber	480	7,560	265	3,830	320	4,350
Sienna	150	4,875	160	3,250	275	6,950
Metallic paint	19,960	297,289	15,225	189,922	17,315	212,761
Mortar color			10,150	94,961	11,544	106,381
Venetian red	3,214	64,400	2,983	73,300	4,595	102,900
Zinc white	24,059	1,804,420	19,987	1,399,090	20,710	1,449,700
Mineral black	70	840	650	14,000	(a)	(a)
Soapstone	100	700	75	525	270	3,200
Slate	3,183	24,727	2,650	21,370	4,331	45,682
Other colors	50	600	....	....	....	....
Total	61,783	2,334,804	61,913	1,897,183	71,405	2,071,252

Kind.	1896.		1897.	
	Short tons	Value.	Short tons.	Value.
Ocher	14,074	$136,458	14,006	$162,764
Umber	165	2,646	[b] 1,080	11,710
Sienna	395	5,416	620	10,610
Metallic paint	14,805	180,134	16,699	187,694
Mortar color	9,660	89,600	8,237	75,570
Venetian red	4,138	93,866	13,603	294,744
Zinc white	20,000	1,400,000	25,000	1,750,000
Mineral black	(a)	(a)	(a)	(a)
Soapstone	....	....	2	20
Slate	4,795	44,835	4,666	46,681
Other colors	....	....	[c] 2,000	6,000
Total	68,032	1,952,955	85,913	2,545,793

[a] Included in slate.

[b] Includes 600 tons of "Spanish brown."

[c] Graphitic shale.

OCHER, UMBER, AND SIENNA.

Ocher is an impure hydrated oxide of iron or silicate of alumina colored by iron. Its color is usually yellow, but sometimes red or brown. The common form of ocher used commercially as a pigment is yellow in color, but of a great variety of shades, beauty, and opacity. Umber and sienna differ in composition from ocher in that manganese is present in addition to oxide of iron. Raw umber is used by painters as a brown color. Burnt umber is of somewhat richer and redder tinge than the raw, and is very popular. Sienna may be said to come between the other two. Used raw it is of a brownish-yellow hue. When burnt a redder tinge is developed, which makes a pigment of a rich russet brown.

These pigments are notable not only for their stability of color, but because they may be used with either oil or water as a vehicle for painting, in frescoing, and in the manufacture of wall paper and other colored papers.

PRODUCTION.

Ocher was produced in eleven States during 1897, viz: Alabama, California, Georgia, Iowa, Kansas, Maryland, Missouri, New York, Pennsylvania, Vermont, and Virginia. In each of these States, excepting Georgia, Pennsylvania, and Vermont, there were only one or two producers, and the output of the other eight States is combined in order not to divulge individual statistics. The three States mentioned produced more than two and one-half times the output of the other eight States. Pennsylvania alone produced nearly one-half the entire output.

Umber and sienna were produced in three States—New York, Pennsylvania, and Missouri, Pennsylvania producing more than nine-tenths of the former and more than one-half of the latter. Maryland is credited with 600 tons of Spanish brown, a product not reported from any other locality.

The following tables show the production of ocher, umber, and sienna. during 1896 and 1897 by States:

Production of ocher in 1896 and 1897, by States.

State.	1896.		1897.	
	Short tons.	Value.	Short tons.	Value.
Georgia	2,981	$28,005	2,608	$36,600
Pennsylvania	2,926	26,818	6,825	81,325
Vermont	....	....	693	7,739
Other States	8,167	81,635	3,880	37,100
Total	14,074	136,458	14,006	162,764

Production of umber and sienna in 1896 and 1897.

Year.	Umber.		Sienna.	
	Short tons.	Value.	Short tons.	Value.
1896	165	$2,646	395	$5,416
1897	*a* 1,080	11,710	620	10,610

a Includes 600 tons Spanish brown from Maryland.

For the purposes of comparison the production for the past nine years is shown in the following table. Prior to 1889, when the statistics were compiled for the Eleventh Census, the production for each State was not published:

Production of ocher, umber, and sienna from 1889 to 1897, by States.

State.	1889.		1890.		1891.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Alabama	336	$3,500	350	$4,100	524	$5,840
Colorado	50	150	1,000	15,000	....	....
Georgia	2,512	29,720	800	12,800	600	9,000
Maryland	616	12,000	....	....	....	....
Massachusetts	80	750	300	2,700	300	2,700
Missouri	....	....	2,200	30,000	1,850	27,500
New Jersey	....	....	....	....	600	7,200
New York	....	....	365	4,493	....	....
Pennsylvania	7,922	103,797	4,173	61,458	4,535	56,588
Vermont	1,884	7,800	....	....	935	11,095
Virginia	1,658	18,755	1,367	22,972	1,950	29,900
Wisconsin	100	1,000	....	....	....	....
Other States	....	....	*a* 7,000	84,000	*a* 7,000	84,000
Total	15,158	177,472	17,555	237,523	18,294	233,823

a Includes all of Maryland and estimated product of some firms in other States not reporting.

Production of ocher, umber, and sienna from 1889 to 1897, by States—Continued.

State.	1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Alabama	375	$4,050	350	$3,000	....	....
Georgia	1,748	26,800	2,600	39,000	1,690	$17,840
Maryland	1,000	10,000	....	....	....	....
Massachusetts	46	418	....	....	....	....
Missouri	1,922	28,220	555	5,413	1,800	23,160
New Jersey	175	3,600	....	....	....	....
Pennsylvania	7,055	90,755	5,375	71,575	4,975	47,830
Vermont	544	5,731	523	5,280	336	3,384
Virginia	1,500	23,500	....	....	....	....
Other States	....	....	[a] 1,744	17,560	[b] 1,392	11,801
Total	14,365	193,074	11,147	141,828	10,193	104,015

State.	1895.		1896.		1897.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Georgia	2,105	$31,080	2,981	$28,005	2,608	$36,600
Pennsylvania	[c] 7,395	85,600	[c] 3,486	34,880	7,595	95,245
Vermont	....	....	....	....	693	7,739
Other States [d]	3,140	33,948	8,167	81,635	4,810	45,500
Total	12,640	150,628	14,634	144,520	15,706	185,084

[a] Includes Kentucky, Maryland, Massachusetts, and Virginia.

[b] Includes Alabama, Kentucky, Maryland, Massachusetts, Virginia, and Wisconsin.

[c] Includes Missouri's and New York's product of umber and sienna.

[d] Includes Alabama, California, Iowa, Maryland, Missouri, New York, Vermont, Virginia, and Wisconsin.

Annual production of ocher, etc., since 1884.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1884	7,000	$84,000	1891	18,294	$233,823
1885	3,950	43,575	1892	14,365	193,074
1886	6,300	91,850	1893	11,147	141,828
1887	8,000	75,000	1894	10,193	104,015
1888	10,000	120,000	1895	12,640	150,628
1889	15,158	177,472	1896	14,634	144,520
1890	17,555	237,523	1897	15,706	185,084

IMPORTS.

The following tables show the amount and value of ochers, etc., from 1867 to 1897:

Ocher, etc., imported from 1867 to 1883.

Fiscal year ended June 30—	All ground in oil.		Indian red and Spanish brown.		Mineral French, and paris green.		Other, dry, not otherwise specified.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1867..	11, 373	$385	....	$35, 374	....	$2, 083	1, 430, 118	$9, 923
1868..	6, 949	333	....	11, 165	....	500	3, 670, 093	32, 102
1869..	65, 344	2, 496	2, 582, 335	31, 624	8, 369	2, 495	5, 379, 478	39, 546
1870..	149, 240	6, 042	3, 377, 944	41, 607	9, 618	3, 444	3, 935, 978	32, 593
1871..	121, 080	4, 465	2, 286, 930	40, 663	33, 488	11, 038	2, 800, 148	24, 767
1872..	277, 617	9, 225	2, 810, 282	38, 763	41, 422	10, 341	5, 645, 343	56, 680
1873..	94, 245	3, 850	135, 360	2, 506	34, 382	8, 078	3, 940, 785	51, 318
1874..	98, 176	4, 623	263, 389	3, 772	102, 876	18, 153	3, 212, 988	35, 365
1875..	280, 517	12, 352	646, 009	9, 714	64, 910	13, 506	3, 282, 415	37, 929
1876..	63, 916	3, 365	2, 524, 989	19, 555	21, 222	5, 385	3, 962, 646	47, 405
1877..	41, 718	2, 269	2, 179, 631	24, 218	27, 687	6, 721	3, 427, 208	32, 924
1878..	25, 674	1, 591	2, 314, 028	23, 677	67, 655	14, 376	3, 910, 947	33, 260
1879..	17, 649	1, 141	2, 873, 550	26, 929	17, 598	3, 114	3, 792, 850	42, 563
1880..	91, 293	4, 233	3, 655, 920	32, 726	16, 154	3, 269	4, 602, 546	52, 120
1881..	99, 431	4, 676	3, 201, 880	30, 195	75, 465	14, 648	3, 414, 704	46, 069
1882..	159, 281	7, 915	3, 789, 586	34, 136	18, 293	2, 821	5, 530, 204	68, 106
1883 *a*	137, 978	6, 143	1, 549, 968	13, 788	6, 972	885	7, 022, 615	90, 593

a Since 1883 classified as "dry" and "ground in oil."

Imports of ocher of all kinds from 1884 to 1897.

Year ended—	Dry.		Ground in oil.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*	
June 30, 1884..	6, 164, 359	$63, 973	108, 966	$4, 717	6, 273, 325	$68, 690
1885..	4, 983, 701	51, 499	79, 666	3, 616	5, 063, 363	55, 115
Dec. 31, 1886..	4, 939, 183	53, 593	112, 784	6, 574	5, 051, 967	60, 167
1887..	5, 957, 200	58, 162	54, 104	7, 337	6, 011, 304	65, 499
1888..	6, 574, 608	64, 123	43, 142	9, 690	6, 617, 750	73, 813
1889..	5, 540, 267	52, 502	51, 063	9, 072	5, 591, 330	61, 574
1890..	....	....	....	....	6, 471, 863	71, 953
1891..	6, 246, 890	63, 040	52, 206	5, 272	6, 299, 096	68, 312
1892..	8, 044, 836	97, 946	49, 714	5, 120	8, 094, 550	103, 066
1893..	6, 225, 789	55, 074	52, 468	3, 354	6, 278, 257	58, 428
1894..	4, 937, 738	45, 276	22, 387	2, 100	4, 960, 125	47, 376
1895..	7, 107, 987	56, 020	41. 153	2, 239	7, 149, 140	58, 259
1896..	8, 954, 252	68, 196	27, 023	1, 561	8, 981, 275	69, 757
1897..	*a*7, 720, 075	59, 272	20, 123	1, 000	7, 740, 198	60, 272

a Includes 241,452 pounds entered as crude and 1,416,587 pounds powdered.

Imports of umber from 1867 to 1897.

Year ended—	Quantity.	Value.	Year ended—	Quantity.	Value.
	Pounds.			*Pounds.*	
June 30, 1867..	2, 147, 342	$15, 946	June 30, 1883..	785, 794	$8, 419
1868..	345, 173	2, 750	1884..	2, 946, 675	20, 654
1869..	570, 771	6, 159	1885..	1, 198, 060	8, 504
1870..	708, 825	6, 313	Dec. 31, 1886..	1, 262, 930	9, 187
1871..	470, 392	7, 064	1887..	2, 385, 281	16, 536
1872..	1, 409, 822	18, 203	1888..	1, 423, 800	14, 684
1873..	845, 601	8, 414	1889..	1, 555, 070	20, 887
1874..	729, 864	6, 200	1890..	1, 556, 823	19, 329
1875..	513, 811	5, 596	1891..	633, 291	6, 498
1876..	681, 199	7, 527	1892..	1, 028, 038	6, 256
1877..	1, 101, 422	10, 213	1893..	1, 488, 849	16, 636
1878..	1, 038, 880	8, 302	1894..	632, 995	6, 275
1879..	986, 105	6, 959	1895..	*a*1, 560, 786	13, 075
1880..	1, 877, 645	17, 271	1896..	*b*689, 075	8, 360
1881..	1, 475, 835	11, 126	1897..	*c*1, 447, 889	14, 479
1882..	1, 923, 648	20, 494			

a Includes 6,137 pounds ground in oil and 1,554,649 pounds dry.
b Includes 5,292 pounds ground in oil and 683,783 pounds dry.
c Includes 14,471 pounds ground in oil and 1,433,418 pounds dry—crude or powdered.

Imports of Sienna since 1893.

Year ended—	Dry.		Ground in oil.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
Dec. 31, 1893	1, 626, 536	$138, 889	5, 857	$610
1894	337, 909	9, 424	18, 877	895
1895	456, 861	11, 021	6, 576	501
1896				
1897	580, 468	12, 340	7, 058	481

The following table indicates the output of ocher in some of the principal producing countries for years for which comparable statistics are available. France leads in amount, with the United States second, the positions being reversed when the value is taken. The United Kingdom is third and the German Empire fourth both in amount and value of the product:

Production of ocher in principal producing countries from 1893 to 1897.

Year.	United States.		United Kingdom.		France.		German Empire.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1893 .	11,147	$141,828	11,798	$67,318	....	....	....	....
1894 .	10,193	104,015	9,538	68,094	....	....	....	....
1895 .	12,640	150,628	8,540	82,397	36,456	$142,756	9,911	$25,297
1896 .	14,634	144,520	11,078	99,737	30,304	125,164	9,918	26,227
1897 .	15,706	185,084	....	....	....	....	....	....

Year.	Canada.		Belgium.		Spain.		Cyprus.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1893 .	1,070	$17,710	1,408	$1,351	1,135	$685	....	....
1894 .	611	8,690	400	965	132	232	1,714	$3,822
1895 .	1,339	14,600	800	1,930	224	760	1,500	3,293
1896 .	2,362	16,045	1,120	2,702	234	820	3,240	6,955

METALLIC PAINT.

Including the portion of the product used for mortar color, the amount of hematite iron ore ground for pigment in 1897 was 24,936 short tons, against 24,465 short tons in 1896. Deducting the production of mortar color, of which there were 9,660 tons in 1896 and 8,237 tons in 1897, the output of metallic paint in 1897 was 16,699 short tons, compared with 14,805 short tons in 1896—an increase of 1,894 short tons, or about 13 per cent. The total value of the metallic-paint product increased from $180,134 to $187,694, a gain of only 4 per cent as compared with an increase of 13 per cent in the product. The noteworthy feature of the metallic-paint industry in 1897 was the decline in price. Prices have been unsatisfactory and steadily declining since 1893, when the average price realized was $14.89 per short ton, and this included the amount and value of the mortar colors produced that year. The mortar-color pigment is usually a lower grade of material than that used for metallic paint, so that if any separation had been made in 1893 the average price for metallic paint would doubtless have been more than the figures stated. In 1894 the average price for metallic paint alone was $12.47, or $2.42 less than the combined average price in 1893. In 1895 the price had further declined to $12.29; again to $12.17 in 1896, while in 1897 it fell to $11.24, the lowest figure ever reached. The price of mortar color also declined, but not so much, the average price being $9.28 in 1896 and $9.17 in 1897.

The annual product of metallic paint for the past eight years has been as follows:

Production of metallic paint since 1889, by States.

State.	1889.		1890.		1891.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Colorado	90	$2,500	1,300	$22,100	....	....
New York	3,658	63,698	5,224	72,952	7,352	$99,487
Ohio	540	11,123	637	16,341	800	14,500
Pennsylvania	8,849	128,036	8,935	145,243	9,175	134,138
Tennessee	3,057	24,237	5,386	46,088	4,000	30,000
Vermont	....	....	500	6,000	400	5,000
Wisconsin	1,832	26,700	2,125	31,035	2,343	34,375
Other States	3,000	30,000	50	610	1,072	16,955
Total *a*	21,026	286,294	24,177	340,369	25,142	334,455

State.	1892.		1893.	
	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*	
New York	5,200	$76,500	3,885	$57,500
Ohio	879	17,090	710	5,750
Pennsylvania	10,289	176,785	8,300	143,875
Tennessee	5,000	32,000	3,000	27,500
Vermont	400	5,000	338	4,600
Wisconsin	2,448	33,826	2,246	29,500
Other States	1,495	21,765	1,481	28,564
Total *a*	25,711	362,966	19,960	297,289

a Including mortar colors.

Production of metallic paint since 1889, by States—Continued.

State.	1894.		1895.	
	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*	
Missouri	....	....	860	$11,565
New York	4,787	$48,899	6,023	67,161
Ohio	1,006	13,516	....	....
Pennsylvania	8,683	119,674	9,098	126,400
Tennessee	5,510	37,870	5,936	38,602
Vermont	280	3,500	....	....
Wisconsin	3,057	41,889	3,486	44,476
Other States	2,052	19,535	3,456	30,938
Total	25,375	284,883	28,859	319,142
Less mortar colors	10,130	94,961	11,544	106,381
Total metallic paint	15,225	189,922	17,315	212,761

State.	1896.		1897.	
	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*	
New York	5,882	$61,800	5,775	$59,875
Ohio	1,346	11,937	1,626	12,945
Pennsylvania	4,824	76,879	7,788	109,030
Tennessee	6,400	47,200	6,468	43,276
Vermont	....	....	....	....
Wisconsin	1,417	18,958	1,627	19,043
Other States	4,596	52,960	1,652	19,095
Total	24,465	269,734	24,936	263,264
Less mortar colors	9,660	89,600	8,237	75,570
Total metallic paint	14,805	180,134	16,699	187,694

VENETIAN RED.

Venetian red is a bright-red pigment obtained by roasting iron sulphate or green vitriol. The sulphur is driven off, leaving iron oxide of a brighter red than that found native. The amount of iron so consumed is comparatively small when considered with the total iron product, and the venetian-red product is accordingly included in the output of mineral paints.

The production of venetian red in 1897 shows a remarkable increase over that of any previous year. This increase was due partly to an increased output from the manufacturers who have contributed to the production in previous years and partly to the production of this pigment during 1897 in two States, Illinois and Maryland, from which no production had been formerly reported. The production reported in 1897 was nearly three times that of 1892, which year was credited with the largest previous production, and more than three times that of 1896. A slight decline from $22.68 to $21.67 is found in the average price.

The annual production since 1890 has been as follows:

Production of venetian red since 1890.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1890	4,000	$84,100	1894	2,983	$73,300
1891	4,191	90,000	1895	4,595	102,900
1892	4,900	106,800	1896	4,138	93,866
1893	3,214	64,400	1897	13,603	294,744

SLATE GROUND FOR PIGMENT.

Including "mineral black," a pigment made from the slate partings and roofs in anthracite collieries, the amount of slate and shale ground for paint in 1897 was 4,666 short tons, a product less than that of the preceding year by 129 tons. In the production of this variety of pigment an exception to the rule is noted, in that the value per ton in 1897 was more than that which obtained in 1896. In the former year the average price was $9.35. In 1897 it advanced to $10, but was still 55 cents less than the price for 1895.

The annual product of pigments made from slate and shale since 1880 has been as follows:

Amount and value of slate and shale ground for pigment since 1880.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1880	1,120	$10,000	1889	2,240	20,000
1881	1,120	10,000	1890	2,240	20,000
1882	2,240	24,000	1891	2,240	20,000
1883	2,240	24,000	1892	3,787	23,523
1884	2,240	20,000	1893	3,253	25,567
1885	2,212	24,687	1894	3,300	35,370
1886	3,360	30,000	1895	4,331	45,682
1887	2,240	20,000	1896	4,795	44,835
1888	2,800	25,100	1897	4,666	46,681

WHITE LEAD, ETC.

The production of white lead in the United States in 1897 was the largest on record. The same is true in regard to the production of red lead. The production of litharge in 1897 was exceeded by that of only one other year—1895. The output of orange mineral in 1897 was the largest ever obtained.

The production of white lead, red lead, litharge, and orange mineral, dry and in oil, with the value of each, in 1897, was as follows:

Production of white lead, etc., dry and in oil, in 1897.

	White lead.		Red lead.	
	Pounds.	Value.	Pounds.	Value.
Dry	33,720,684	$1,376,932	15,317,199	$731,312
In oil	157,596,111	8,299,883	....	....
Total	191,316,795	9,676,815	15,317,199	731,312
	Litharge.		Orange mineral.	
	Pounds.	Value.	Pounds.	Value.
Dry	13,266,322	$572,896	901,560	$55,468

The production of white lead, red lead, litharge, and orange mineral, dry and in oil, with the value of each, in 1896, was as follows:

Production of white lead, etc., dry and in oil, in 1896.

	White lead.		Red lead.	
	Pounds.	Value.	Pounds.	Value.
Dry	26,638,373	$1,058,555	11,432,166	$530,260
In oil	150,578,451	7,313,033	30,000	1,800
Total	177,216,824	8,371,588	11,462,166	532,060
	Litharge.		Orange mineral.	
	Pounds.	Value.	Pounds.	Value.
Dry	12,980,221	$539,700	539,700	$33,132

As will be seen by the above tables, there was an increase of about 14,000,000 pounds in the production of white lead in 1897 over 1896, the increase being nearly equally divided between the output of "dry" lead and lead "in oil." The production of red lead in 1897 was 3,855,000 pounds larger than that of 1896, but only 1,800,000 more than that of 1895. Litharge production in 1897 was nearly 300,000 pounds more than in 1896, but was more than 700,000 pounds short of the product in 1895. The product of orange mineral was 901,560 pounds in 1897, an increase of nearly 70 per cent over the previous year.

The following table exhibits, with quantities expressed in short tons, the annual production of white lead, red lead, etc., for a series of seven years. Previous to 1894 the values were based on white lead in oil. The statistics for the past four years include the amount of lead sold, dry and in oil, with the value in the condition in which it was sold.

Production of white lead, etc., for seven years.

	1891.		1892.		1893.		1894.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
White lead ...	78,018	$10,454,029	74,485	$8,733,620	72,172	$7,695,130	76,343	$6,623,071
Red lead......	4,607	591,730	6,122	757,787	6,377	732,968	6,465	623,021
Litharge......	5,759	720,925	5,764	611,726	11,757	1,154,819	5,652	495,406
Orange mineral.........	330	43,300	395	60,170	217	32,893	319	43,517

	1895.		1896.		1897.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
White lead	90,513	$8,723.632	88,608	$8,371,588	95,658	$9,676,815
Red lead............................	6,756	628,133	5,731	532,060	7,659	731,312
Litharge............................	6,987	601,267	6,490	539,700	6,633	572,896
Orange mineral......................	366	44,749	270	33,132	451	55,468

The annual production of white lead since 1884 has been as follows:

Production of white lead in the United States since 1884.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1884...........	65,000	$6,500,000	1891...........	78,018	$10,454,029
1885...........	60,000	6,300,000	1892...........	74,485	8,733,620
1886...........	60,000	7,200,000	1893...........	72,172	7,695,130
1887...........	70,000	7,560,000	1894...........	76,343	6,623,071
1888...........	84,000	10,080,000	1895...........	90,513	8,723,632
1889...........	80,000	9,600,000	1896...........	88,608	8,371,588
1890...........	77,636	9,382,967	1897...........	95,658	9,676,815

IMPORTS.

The following table shows the imports of white lead, red lead, litharge and orange mineral since 1867:

Red lead, white lead, litharge, and orange mineral imported from 1867 to 1897.

Year ended—	Red lead.		White lead.		Litharge.		Orange mineral.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
June 30, 1867.....	926,843	$53,087	6,636,508	$430,805	230,382	$8,941	....	....
1868.....	1,201,144	76,773	7,533,225	455,698	250,615	12,225	....	....
1869.....	808,686	46,481	8,948,642	515,783	187,333	7,767	....	....
1870.....	1,042,813	54,626	6,228,285	365,706	97,398	4,442	....	....
1871.....	1,295,616	78,410	8,337,842	483,392	70,889	3,870	....	....
1872.....	1,513,794	85,644	7,153,978	431,477	66,544	3,396	....	....
1873.....	1,583,039	99,891	6,331,373	408,986	40,799	2,379	....	....
1874.....	756,644	56,805	4,771,509	323,926	25,687	1,450	....	....
1875.....	1,048,713	73,131	4,354,131	295,642	15,767	950	....	....
1876.....	749,918	54,884	2,546,776	175,776	47,054	2,562	....	....
1877.....	387,260	28,747	2,644,184	174,844	40,331	2,347	....	....
1878.....	170,608	9,364	1,759,608	113,638	28,190	1,499	....	....
1879.....	143,237	7,237	1,274,196	76,061	38,495	1,667	....	....
1880.....	217,033	10,397	1,906,931	107,104	27,389	1,222	....	....
1881.....	212,423	10,009	1,068,030	60,132	63,058	2,568	....	....
1882.....	288,946	12,207	1,161,889	64,493	54,592	2,191	....	....
1883.....	249,145	10,503	1,044,478	58,588	34,850	1,312	....	....
1884.....	265,693	10,589	902,281	67,918	54,183	1,797	....	....
1885.....	216,449	7,641	705,535	40,437	35,283	1,091	....	....
Dec. 31, 1886.....	597,247	23,038	785,554	57,340	51,409	1,831	....	....
1887.....	371,299	16,056	804,320	58,602	35,908	1,302	....	....
1888.....	520,665	23,684	627,900	49,903	62,211	2,248	....	....
1889.....	522,026	24,400	661,694	56,875	41,230	1,412	....	....
1890.....	450,402	20,718	742,196	57,659	48,283	2,146	....	....
1891.....	651,577	23,807	718,228	40,773	94,586	3,108	....	....
1892.....	812,703	28,443	744,838	40,032	56,737	1,811	1,409,601	$64,133
1893.....	854,982	27,349	686,490	34,145	42,582	1,310	1,385,828	61,360
1894.....	947,873	29,064	796,480	40,939	38,595	1,064	1,386,464	58,614
1895.....	1,764,274	53,139	1,897,892	79,887	97,667	2,812	1,689,367	66,492
1896.....	1,543,262	47,450	1,183,538	52,409	51,050	1,615	1,359,651	51,027
1897.....	1,386,070	46,992	1,101,829	43,988	60,984	1,931	1,486,042	67,549

PRICES.

The following table is of interest, as it shows the average yearly prices of pig lead and white lead in oil (both at New York) and the difference between the two since 1874:

Average yearly net prices, at New York, of pig lead and white lead in oil since 1874.

[Per 100 pounds.]

Year.	Pig lead, in New York.	White lead in oil, in New York.	Difference.	Year.	Pig lead, in New York.	White lead in oil, in New York.	Difference.
1874.....	$6.00	$11.25	$5.25	1886.....	$4.63	$6.25	$1.62
1875.....	5.95	10.50	4.55	1887.....	4.47	5.75	1.28
1876.....	6.05	10.00	3.95	1888.....	4.41	5.75	1.34
1877.....	5.43	9.00	3.57	1889.....	3.80	6.00	2.20
1878.....	3.58	7.25	3.67	1890.....	4.33	6.25	1.92
1879.....	4.18	7.00	2.82	1891.....	4.33	6.37	2.05
1880.....	5.05	7.60	2.55	1892.....	4.05	6.39	2.34
1881.....	4.80	7.25	2.45	1893.....	3.73	6.03	2.30
1882.....	4.90	7.00	2.10	1894.....	3.28	5.26	1.98
1883.....	4.32	6.88	2.56	1895.....	3.12	5.05	1.93
1884.....	3.73	5.90	2.17	1896.....	3.03	4.90	1.87
1885.....	3.95	6.00	2.05	1897.....	3.64	5.00	1.36

The market for pig lead in 1897 opened at 3.15 cents per pound. It gradually advanced until September, when it reached 4.42½ cents. It then gradually declined, and at the close of the year was 3.75 cents. The average for the year was 3.64 cents.

In considering the variations between the value of pig lead and white lead in oil allowance should be made for the fluctuations in the value of linseed oil, which enters largely into the manufacture of lead in oil. The fluctuations in the price of linseed oil in four years have ranged from 30 cents to 59 cents a gallon. The highest price reached for linseed oil was in July, 1895, and the lowest in the early part of 1897. The highest price for linseed oil in 1897 was 43 cents, the closing figures for the year. The fluctuations in the price of linseed oil in four years have been as follows, in cents per gallon:

	Highest.	Lowest.
1894	56	50
1895	59	42
1896	41	31
1897	43	30

The proportions of white lead and oil vary according to trade requirements, but on an average 100 pounds of lead in oil contain 91 pounds of lead and 9 pounds of linseed oil.

ZINC WHITE.

The production of zinc oxide, or zinc white, in the United States for the year 1897 may be placed at 25,000 short tons, this estimate being based upon accurate returns from the leading producer. The estimate for 1896 was 20,000 short tons, thus showing that an increase has taken place. The consolidation in 1896 of all the largest producers has brought under one progressive management practically the entire capacity of the United States. During the current year plans are being developed for the ultimate concentration in one locality of the different producing plants in the East, the Passaic, Lehigh, and New Jersey works, the object being to reduce cost by lower taxation, cheaper fuel, and lessened expenses of management. The locality selected is Lehigh Gap, Pennsylvania, between Mauch Chunk and Slatington, on the New Jersey Central Railroad. For the present the new works will merely lead to a gradual abandonment of the other plants, but the ultimate object is the expansion of the new plant in accordance with the development of the demand.

In the following table is shown the production of zinc white from 1880 to 1897:

Production of zinc white since 1880.

Year.	Quantity.	Value.
	Short tons.	
1880	10,107	$763,738
1881	10,000	700,000
1882	10,000	700,000
1883	12,000	840,000
1884	13,000	910,000
1885	15,000	1,050,000
1886	18,000	1,440,000
1887	18,000	1,440,000
1888	20,000	1,600,000
1889	16,970	1,357,600
1890	....	1,600,000
1891	23,700	1,600,000
1892	27,500	2,200,000
1893	24,059	1,804,420
1894	19,987	1,399,090
1895	20,710	1,449,700
1896	20,000	1,400,000
1897	25,000	1,750,000

IMPORTS.

The imports of zinc white in 1897 show an increase of about the same proportion over 1896 as the increase in production. The total imports of zinc white, dry and in oil, in 1896 amounted to 4,883,804 pounds, and in 1897 the imports amounted to 6,067,120 pounds, an increase of 1,183,316 pounds, or practically 25 per cent. The domestic production in 1897 showed the same percentage of increase.

The following table shows the amount of zinc white imported into the United States since 1885:

Imports of zinc oxide from 1885 to 1897, inclusive.

Year ended—	Dry.	In oil.	Year ended—	Dry.	In oil.	Total value.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	
June 30, 1885.	2, 233, 128	98, 566	Dec. 31, 1891..	2, 839, 351	128, 140	....
Dec. 31—			1892..	2, 442, 014	111, 190	....
1886.....	3, 526, 289	79, 788	1893..	3, 900, 749	254, 807	....
1887.....	4, 961, 080	123, 216	1894..	3, 371, 292	59, 291	$122, 690
1888.....	1, 401, 342	51, 985	1895..	4, 546, 049	129, 343	153, 641
1889.....	2, 686, 861	66, 240	1896..	4, 572, 781	311, 023	161, 188
1890.....	2, 631, 458	102, 298	1897..	5, 564, 763	502, 357	206, 636

BARYTES.

By Edward W. Parker.

PRODUCTION.

The amount of crude barytes (heavy spar) produced in the United States during 1897 was 26,042 short tons, valued at $58,295, an increase of a little more than 52 per cent in quantity over that of 1896, but of only 25 per cent in value. The average value per ton realized in 1897 was the lowest ever known. The decline in price was not entirely due to a general falling off in value, but was caused in part by an increased output of low-grade barytes, which sold for $1 per ton at the mines and which affected the general average. There was, however, a moderate decline in all grades. Taking the total product and value in 1897 and comparing them with those of previous years, it is found that there has been an uninterrupted decline in price since 1894. A spirit of competition between Eastern and Western producers may be held responsible for any decline other than that in 1897 referred to above. The general average has declined from $3.73 per ton in 1894 to $3.17 in 1895, $2.72 in 1896, and $2.24 in 1897, the price in 1897 being about 40 per cent less than in 1894 and nearly 18 per cent less than in 1896. How much of the difference between the prices in 1896 and 1897 was due to the production of low-grade material and how much to other causes is shown to some extent by the fact that in Missouri the average price per ton in 1897 was $2.82 against $2.92 the previous year. About two-fifths of the product in 1897 was from Missouri, 10,440 tons being credited to that State against 8,768 tons in 1896. About half of the total product in 1896 was from the Eastern States of Virginia and North and South Carolina. These States in 1897 produced about 15,600 tons, nearly double their output in 1896.

The production of crude barytes in the United States since 1882 has been as follows:

Production of crude barytes from 1882 to 1897.

Year.	Quantity.	Value.	Average price per ton.	Year.	Quantity.	Value.	Average price per ton.
	Short tons.				*Short tons.*		
1882......	22,400	$80,000	$3.57	1890.......	21,911	$86,505	$3.95
1883......	30,240	108,000	3.57	1891.......	31,069	118,363	3.81
1884......	28,000	100,000	3.57	1892.......	32,108	130,025	4.05
1885......	16,800	75,000	4.46	1893.......	28,970	88,506	3.06
1886......	11,200	50,000	4.46	1894.......	23,335	86,983	3.73
1887......	16,800	110,000	*a*6.55	1895.......	21,529	68,321	3.17
1888......	22,400	75,000	3.35	1896.......	17,068	46,513	2.72
1889......	21,460	106,313	*b*4.95	1897.......	26,042	58,295	2.24

a Value at St. Louis and includes some floated barytes.
b Value includes floated barytes when sold first in that form.

IMPORTS.

The following table shows the imports of barytes into the United States from 1867 to 1897:

Imports of barytes from 1867 to 1897.

Year ended—	Manufactured.		Unmanufactured.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
June 30, 1867..................	14,968,181	$141,273	....	....
1868..................	2,755,547	26,739	....	....
1869..................	1,117,335	8,565	....	....
1870..................	1,684,916	12,917	....	....
1871..................	1,385,004	9,769	....	....
1872..................	5,804,098	43,521	....	....
1873..................	6,939,425	53,759	....	....
1874..................	4,788,966	42,235	....	....
1875..................	2,117,854	17,995	....	....
1876..................	2,655,349	25,325	....	....
1877..................	2,388,373	19,273	....	....
1878..................	1,366,857	10,340	....	....
1879..................	453,333	3,496	....	....
1880..................	4,924,423	37,374	....	....
1881..................	1,518,322	11,471	....	....
1882..................	562,300	3,856	....	....
1883..................	411,666	2,489	....	....

Imports of barytes from 1867 to 1897—Continued.

Year ended—	Manufactured.		Unmanufactured.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
Dec. 31, 1884	3,884,516	$24,671	5,800,816	$8,044
1885	4,095,287	20,606	7,841,715	13,567
1886	3,476,691	18,338	6,588,872	8,862
1887	4,057,831	19,769	10,190,848	13,290
1888	3,821,842	17,135	6,504,975	9,037
1889	3,601,506	22,458	13,571,206	7,660
1890	*a* 1,563	16,453	*a* 4,815	13,133
1891	2,149	22,041	2,900	8,816
1892	1,389	15,419	2,789	7,418
1893	1,032	11,457	2,983	7,612
1894	836	10,556	1,884	5,270
1895	1,629	17,112	2,551	7,561
1896	2,467	23,345	509	1,274
1897	1,300	13,822	502	579

a Tons since 1890.

FULLER'S EARTH.

PRODUCTION.

The chief producing locality continues to be Quincy, Florida, from the mines already described in previous reports, with a small production from the localities indicated in the following table:

Production of fuller's earth in the United States, 1895 to 1897, inclusive.

	1895.		1896.		1897.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
Colorado	....	....	....	....	50	$100
Florida	6,900	$41,400	9,872	$59,360	16,863	110,172
New York	....	....	....	....	200	2,000
Total	6,900	41,400	9,872	59,360	17,113	112,272

The total quantity was 17,113 tons, valued at $112,272, in 1897, which was a satisfactory advance over the year before, and gives rise to the belief that a few years will see much of the importation supplied by domestic material.

A peculiar chocolate-brown earth was discovered in the neighborhood of Ocala, Florida, during 1897, which proved to have a capacity for filtering lubricating oils and many other liquids superior to that of ordinary American or English fuller's earth. The material as exposed in the sides of certain sinks was several feet in thickness, but not enough exploratory work was done to determine the area of the deposits. The material in place resembles chocolate. The following chemical examination shows that it resembles fuller's earth quite markedly, although impure by containing sand and a small amount of organic matter, to which its brown color is partly due, and by carrying most persistently a small percentage of phosphate of aluminum. This phosphate of aluminum remained with the clay portion after all the sand and most of the organic matter had been removed by washing with water. The material has as yet received no name. It will probably become an important rival of fuller's earth in the future.

The following analyses show the relation of this material to other varieties of fuller's earth:

Analyses of fuller's earth from England and Florida.

	England.		Florida.
	No. 1 (blue earth).	No. 2 (yellow earth).	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
SiO_2	52.81	59.37	36.73
Al_2O_3	6.92	11.82	27.78
Fe_2O_3	3.78	6.27	3.21
CaO	7.40	6.17	.81
MgO	2.27	2.09	.64
P_2O_5	.27	.14	5.54
SO_3	.05	.07	
NaCl	.05	.14	
K_2O	.74	.84	.42
H_2O	14.27	13.19	[a] 7.38
H_2O			[b] 12.14
TiO_2			1.27
CO_2			None.
Na_2O			None.
Organic matter			3.61

[a] At 110°.

[b] Above 110°.

Nebraska.—During the year samples of fuller's earth from Valentine, Nebraska, were examined and found to compare quite favorably with the fuller's earth from Florida and from England. The vein of it, however, is reported as thin, and no decision has been arrived at as to whether the material will be put upon the market.

QUARTZ AND FELDSPAR.

PRODUCTION.

Although the number of firms reporting for 1897 was less than for 1896, still the totals for the former are larger. This is no doubt due to the increased activity in the pottery industry in this country. No new deposits are known to have been opened up.

The following are the figures of production for 1897, those for 1896 being also given for comparison:

Production and value of feldspar in 1896 and 1897, by States.

State.	1896.		1897.	
	Long tons.	Value.	Long tons.	Value.
Connecticut	1,410	$5,050	6,175	$24,875
Maine and Pennsylvania	3,360	12,000	4,500	16,575
Massachusetts	1,344	6,300	100	450
Maryland	2,700	9,300	....	....
New York	300	2,550	400	1,200
Total	9,114	35,200	11,175	43,100

Production and value of quartz in 1896 and 1897, by States.

State.	1896.		1897.	
	Long tons.	Value.	Long tons.	Value.
Alabama	....	....	1,500	$7,500
Connecticut	1,568	$5,600	1,200	3,000
Maine	3,136	5,376	250	525
Maryland	5,300	10,750	4,300	4,100
Massachusetts	1,120	2,500	500	1,000
New York	....	....	1,200	2,100
Pennsylvania	....	....	1,502	1,502
Wisconsin	....	....	1,500	6,500
Total	11,124	24,226	11,952	26,227

MINERAL WATERS.

By A. C. PEALE.

PRODUCTION.

The list of commercial springs for 1897 is the largest yet published, containing 64 springs more than the list for 1896. The number of springs actually added is 69, but 5 springs were taken from the list, as they have gone out of business or have not been heard from for a number of years. The number of springs heard from for 1897 is 381, just 69 more than reported for 1896. Many of them were springs that did not report for 1896, and many of those delinquent for 1897 reported for the previous year. The delinquent list contains 60 springs, and they have been estimated, as usual, at one-half the previously reported figures, except in the cases where it was reported that no sales were made in 1897.

Although the list is larger than for any previous year, the production falls below that of 1896, only two sections reporting increased sales, and in these the increase is largely due to the number of new springs added to the list. The losses in the remaining three sections, however, overbalance this gain. The total production for 1897 is 23,255,911 gallons, which is 2,539,401 gallons less than that of 1896. There is, however, a gain in the value of the production. The total valuation of the product for 1897 is $4,599,106, which is $462,914 more than that of 1896. For the last five years the average price per gallon has been as follows: For 1893, 18 cents; for 1894, 17 cents; for 1895, 19 cents; for 1896, 16¼ cents; for 1897, 20 cents.

Considering only the figures of the 381 springs actually reporting, the decrease in production from 1896 is 1,350,289 gallons, and the increase in valuation over that of the previous year is $664,114.

The total number of springs on our list for the North Atlantic States for 1897 is 140, a net gain of 30 springs over 1896, as 33 have been added and 3 dropped. Reports were received from 125 springs, 35 more than in the previous year. The increase in production, however, is only 473,376 gallons, while its value is $538,021 greater than in 1896. The following springs are new to the list for 1897:

Connecticut: Hartford Lithia Spring, Judges Cave Spring, Live Oak Spring, Stillman Homestead Springs.

Maine: Glenrock Springs, Hartford Cold Spring, Seal Rock Springs.

Massachusetts: Geddes Mineral Spring, Katahdin Spring, Linden Mineral Spring, Myles Standish Spring, Shawmut Spring, Whittier Spring.

New York: Binghamton Vichy Spring, Crystal Rock Spring, Elixir Spring, Halcyon Spring, Kirkland Springs, Oliphant's Mineral Spring, Rigney's Sulphur

Springs, Geyser Spring (Saratoga Springs), Lincoln Spring (Saratoga Springs), Victor Mineral Springs.

Pennsylvania: Cambridge Natural Mineral Springs, De Vita Mineral Springs, Glen Summit Spring, J. W. Lang Mineral Well, Petticord Mineral Springs, Rennyson Tredyffrin Springs, Springboro Mineral Springs.

Rhode Island: Holda Springs.

Vermont: Crystal Spring, Old Sweet Spring.

The South Atlantic States gain 6 springs over 1896. There are added 7, and 1 is dropped, leaving the total number for the section at 80. Of these, 68 report in 1897, which is 8 more than the total number reporting in 1896. Notwithstanding this the production is 61,525 gallons less, and the total valuation $52,691 less than in 1896. The following springs were not on the list for 1896:

Florida: Panacea Mineral Spring, Sierra Madre Springs.

South Carolina: Bellevue Mineral Springs.

Virginia: Ætna Lithia Springs, Jefferson Park Springs, Old Dominion Lithia Springs.

West Virginia: Webster Springs.

In the North Central States the list contains a total of 121 springs, which is a gain of 13 from 1896. Of these, 7 more report in 1897 than in 1896. In all 104 springs have been heard from, but notwithstanding this increase in the number of reports there is a very considerable decrease in the production, which is 1,841,149 gallons less than in 1896. The value of this product is $90,125 less. The following springs are new to the list of 1897:

Illinois: Sylvan Dell Sulpho-Magnesian Spring.

Indiana: Elliott or Willow Valley Springs, Spiceland Mineral Springs.

Michigan: Bromo-Hygeia Springs, Excelsior Springs, Moorman Springs, Ponce de Leon Springs, Sterling Springs.

Ohio: Concord Crystal Spring, Devonian Mineral Spring.

Wisconsin: Acme Spring, Waukesha; Minniska Mineral Spring, Waukesha; Sotarian Spring, Waukesha.

The South Central States are represented on the list of 1897 by 43 spring localities, a net gain of 1 over 1896. Reports were received from 36 in 1897, which is 2 more than were heard from the previous year. The production is 932,310 gallons less than in 1896, and its value falls $126,758 below that of 1896. The springs added to the list are as follows:

Arkansas: Baker Springs.

Texas: High Island Mineral Spring, Farrier Springs.

For the Western States and Territories the gain to the list is 13 springs, and of these 48 report, which is 17 more than were heard from in 1896. There is also an increase in production of 1,117,690 gallons, with an increased valuation of $302,181. The springs on the list of 1897 not in the list of 1896 are as follows:

California: Adams Springs, Bythnia Springs, Castle Rock Natural Mineral Spring, Cook's Springs, Fouts Springs, Highland Springs, Madrone Mineral Springs, Mount Ida Mineral Springs, Samuel Soda Springs.

Colorado: Mumford's Longmont Medicinal Well, Ute and Little Chief Iron Springs.

New Mexico: Hudson Hot Springs, Macbeth Springs.

Production of mineral waters in 1897, by States and Territories.

State or Territory.	Springs reporting.	Product.	Value.
		Gallons.	
Alabama	4	8,500	$17,125
Arkansas	5	40,010	8,001
California	24	1,216,057	573,930
Colorado	10	1,179,820	42,950
Connecticut	8	92,700	6,445
Florida	3	13,000	3,475
Georgia	7	175,500	41,300
Illinois	13	228,330	17,662
Indiana	12	126,820	20,452
Iowa	4	60,150	8,025
Kansas	3	20,015	1,701
Kentucky	4	48,000	9,450
Maine	12	332,917	44,298
Maryland	6	171,100	22,185
Massachusetts	27	3,176,140	192,829
Michigan	18	579,350	105,907
Minnesota	4	1,846,600	36,901
Mississippi	4	194,295	41,999
Missouri	8	194,757	33,183
New Hampshire	3	1,747,500	1,281,250
New Jersey	2	254,000	188,300
New Mexico	5	34,400	10,480
New York	38	2,864,964	655,707
North Carolina	6	89,015	24,006
Ohio	12	347,700	46,200
Oregon	2	28,300	7,160
Pennsylvania	25	1,007,995	215,463
Rhode Island	4	161,600	9,220
South Carolina	4	113,100	22,410
Tennessee	6	81,550	13,865
Texas	13	2,060,292	38,745
Utah	2	8,548	3,044
Vermont	6	70,450	13,845
Virginia	34	617,106	216,533
Washington	3	47,750	4,090
West Virginia	7	40,742	14,058
Wisconsin	28	2,860,909	444,561
Other States (*a*)	5	222,300	68,865
Total	381	22,362,282	4,505,620
Estimated production of springs not reporting sales	60	893,629	93,486
Grand total	441	23,255,911	4,599,106

a These include the States in which only one spring for each has made a report. They are, District of Columbia, Idaho, Montana, Nebraska, and South Dakota.

Production of natural mineral waters from 1883 to 1891.

Geographic division.	Springs reporting.	Gallons sold.	Value.
1883.			
North Atlantic	38	2,470,670	$282,270
South Atlantic	27	312,090	64,973
North Central	37	1,435,809	323,600
South Central	21	1,441,042	139,973
Western	6	169,812	52,787
	129	5,829,423	863,603
Estimated	60	1,700,000	256,000
Total	189	7,529,423	1,119,603
1884.			
North Atlantic	38	3,345,760	328,125
South Atlantic	27	464,718	103,191
North Central	37	2,070,533	420,515
South Central	21	1,526,817	147,112
Western	6	307,500	85,200
	129	7,715,328	1,084,143
Estimated	60	2,500,000	375,000
Total	189	10,215,328	1,459,143
1885.			
North Atlantic	51	2,527,310	192,605
South Atlantic	32	908,692	237,153
North Central	45	2,925,288	446,211
South Central	31	540,436	74,100
Western	10	509,675	86,776
	169	7,411,401	1,036,845
Estimated	55	1,737,000	276,000
Total	224	9,148,401	1,312,845
1886.			
North Atlantic	49	2,715,050	177,969
South Atlantic	38	720,397	123,517
North Central	40	2,048,914	401,861
South Central	31	822,016	58,222
Western	14	781,540	137,796
	172	7,087,917	899,365
Estimated	53	1,862,400	384,705
Total	225	8,950,317	1,284,070

Production of natural mineral waters from 1883 to 1897—Continued.

Geographic division.	Springs reporting.	Gallons sold.	Value.
1887.			
North Atlantic	40	2,571,004	$213,210
South Atlantic	34	614,041	147,149
North Central	38	1,480,820	208,217
South Central	29	741,080	87,946
Western	12	1,236,324	288,737
	153	6,643,269	945,259
Estimated	62	1,616,340	316,204
Total	215	8,259,609	1,261,463
1888.			
North Atlantic	42	2,856,799	247,108
South Atlantic	32	1,689,387	493,489
North Central	38	2,002,373	325,839
South Central	19	426,410	71,215
Western	15	1,853,679	421,651
	146	8,828,648	1,559,302
Estimated	52	750,000	120,000
Total	198	9,578,648	1,679,302
1889.			
North Atlantic	60	4,106,464	471,575
South Atlantic	47	646,239	198,032
North Central	86	6,137,776	604,238
South Central	33	500,000	43,356
Western	32	1,389,992	431,257
Total	258	12,780,471	1,748,458
1890.			
North Atlantic	55	5,043,074	1,175,512
South Atlantic	39	647,625	245,760
North Central	71	5,050,413	737,672
South Central	30	604,571	81,426
Western	25	869,504	253,578
	220	12,215,187	2,493,948
Estimated	53	1,692,231	106,802
Total	273	13,907,418	2,600,750

Production of natural mineral waters from 1883 to 1897—Continued.

Geographic division.	Springs reporting.	Gallons sold.	Value.
1891.			
North Atlantic	62	5,724,752	$1,591,746
South Atlantic	41	796,439	313,443
North Central	68	8,010,556	482,082
South Central	29	629,015	106,022
Western	27	1,123,640	414,564
	227	16,284,402	2,907,857
Estimated	61	2,108,330	88,402
Total	288	18,392,732	2,996,259
1892.			
North Atlantic	65	6,853,722	1,933,416
South Atlantic	47	1,062,945	353,193
North Central	74	11,566,440	1,834,732
South Central	32	693,544	109,334
Western	24	1,261,453	594,469
	242	21,438,104	4,825,144
Estimated	41	438,500	80,826
Total	283	21,876,604	4,905,970
1893.			
North Atlantic	79	8,351,192	1,844,845
South Atlantic	49	1,092,829	304,736
North Central	78	8,833,712	1,073,427
South Central	35	1,139,959	122,331
Western	29	675,041	307,623
	270	20,092,733	3,652,962
Estimated	60	3,451,762	593,772
Total	330	23,544,495	4,246,734
1894.			
North Atlantic	83	8,217,528	1,488,361
South Atlantic	55	660,120	129,143
North Central	82	6,914,900	1,115,322
South Central	37	2,319,813	273,836
Western	29	859,905	274,235
	286	18,972,266	3,280,897
Estimated	71	2,597,342	460,949
Total	357	21,569,608	3,741,846

Production of natural mineral waters from 1883 to 1897—Continued.

Geographic division.	Springs reporting.	Gallons sold.	Value.
1895.			
North Atlantic	88	8,668,907	$1,572,881
South Atlantic	51	953,713	287,623
North Central	92	6,428,582	1,577,118
South Central	35	2,346,806	161,073
Western	31	886,185	292,832
	297	19,284,193	3,891,527
Estimated	73	2,179,350	362,710
Total	370	21,463,543	4,254,237
1896.			
North Atlantic	90	9,234,890	2,069,336
South Atlantic	60	1,306,088	400,408
North Central	97	8,123,080	808,307
South Central	34	4,364,957	255,943
Western	31	1,577,185	400,998
	312	24,606,200	3,934,992
Estimated	65	1,189,112	201,200
Total	377	25,795,312	4,136,192
1897.			
North Atlantic	125	9,708,266	2,607,357
South Atlantic	68	1,244,563	347,717
North Central	104	6,281,931	718,182
South Central	36	2,432,647	129,185
Western	48	2,694,875	703,179
	381	22,362,282	4,505,620
Estimated	60	893,629	93,486
Total	441	23,255,911	4,599,106

LIST OF COMMERCIAL SPRINGS.

The list given below contains only the names of springs actually reporting for the year 1897.

ALABAMA.

There is no change in the list of springs for Alabama, and the 4 springs credited to the State all report. They are the following:

Bailey Springs, Bailey Springs, Lauderdale County.
Healing Springs, Healing Springs, Washington County.
Jackson White Sulphur Springs, Jackson, Clarke County.
Wilkinson's Matchless Mineral Water, Greenville, Butler County.

ARKANSAS.

Arkansas gains 1 new spring and loses 1, leaving the total the same for 1897 as for 1896, viz, seven. Of these, the following 5 report:

Arkansas Lithia Springs, Hope, Hempstead County.
Baker Springs, Howard County.
Blanco Springs, near Hot Springs, Garland County.
Eureka Springs, Eureka Springs, Carroll County.
Potash Sulphur Spring, Hot Springs, Garland County.

CALIFORNIA.

The list for California is increased by 9 new springs, bringing the total up to 30. Of these, all but 6 report for 1897. The springs reporting are the following:

Adams Springs, Lake County.
Ætna Springs, Lidell, Napa County.
Alhambra Mineral Spring, Martinez, Contra Costa County.
Almaden Vichy Springs, New Almaden, Santa Clara County.
Azule Natural Seltzer Water, San Jose, Santa Clara County.
Bartlett Springs, Bartlett Springs, Lake County.
Bythnia Springs, Santa Barbara,, Santa Barbara County.
Byron Hot Springs, Byron Hot Springs, Contra Costa County.
Castle Rock Natural Mineral Spring, Castella, Shasta County.
Cooks Springs, Colusa County.
Coronado Mineral Spring, Coronado, San Diego County.
Fouts Springs, Colusa County.
Highland Springs, near Clear Lake, Lake County.
Lytton Seltzer Spring, Lytton, Sonoma County.
Lytton Soda Spring, Lytton, Sonoma County.
Madrone Mineral Springs, Santa Clara County.
Matilija Hot Springs, Matilija, Ventura County.
Mount Ida Mineral Spring, Oroville, Butte County.
Napa Soda Springs, Napa Soda Springs, Napa County.
Samuel Soda Springs, Napa County.
Shasta Springs, Shasta Springs, Siskiyou County.
Tolenas Springs, near Suisun, Solano County.
Tuscan Springs, Redbluff, Tehama County.
Veronica Springs, Santa Barbara, Santa Barbara County.

COLORADO.

Two springs are added to the list for Colorado, making 10 in all, and reports have been received from all of them. They are:

Boulder Springs, Boulder Canyon, Boulder County.
Canyon City Vichy Springs, Canyon City, Fremont County.
Carlile Soda-Iron Springs, near Pueblo, Pueblo County.
Colorado Carlsbad Springs, Barr, Arapahoe County.
Clark Magnetic Mineral Springs, near Pueblo, Pueblo County.
Glenwood Springs, Glenwood Springs, Garfield County.
Hiawatha and Ute Chief Springs, Manitou, El Paso County.
Navajo Mineral Springs, Manitou, El Paso County.
Mumford's Medicinal Well, Longmont, Boulder County.
Ute and Little Chief Iron Springs, Manitou, El Paso County.

CONNECTICUT.

The list for Connecticut gains 4 springs. Of the 12 now credited to the State, the following 8 report:

Althea Springs, Waterbury, New Haven County.
Arethusa Springs, Seymour, New Haven County.
Aspinock Mineral Springs, Putnam Heights, Windham County.
Hartford Lithia Spring, Bloomfield, Hartford County.
Judges' Cave Spring, West Rock, New Haven County.
Live Oak Spring, Meriden, New Haven County.
Stillman Homestead Springs, Bridgeport, Fairfield County.
The Puritan Spring, Norwich, New London County

DISTRICT OF COLUMBIA.

The District of Columbia is still represented on the list by 1 spring, as follows:

Columbia Natural Lithia Spring, Washington.

FLORIDA.

Two springs new to the list are added to Florida's representation, making a total of 3, all of which report. They are:

Magnolia Springs, Magnolia Springs, Clay County.
Panacea Mineral Springs, Wakulla County.
Sierra Madre Springs, Pensacola, Escambia County.

GEORGIA.

Of the 8 springs credited to Georgia all but 1 have been heard from. They are as follows:

Austell Lithia Springs, Austell, Cobb County.
Bowden Lithia Springs, Lithia Springs, Douglas County.
Daniels Spring, Greene City, Greene County.
Electric Spring, Hillman, Taliaferro County.
Hillman's Antifebrile Spring, Hillman, Taliaferro County.
Hughes Mineral Spring, near Rome, Floyd County.
Ponce de Leon Spring, near Atlanta, Fulton County.

IDAHO.

There is no change in the number of springs reported for Idaho. It is still represented by 1 spring, as follows:

Idanha Spring, Soda Springs, Bannock County.

ILLINOIS.

One spring is added to the list for Illinois, making the total 17. Of these 13 report, as follows:

Aurora Lithia Spring, Montgomery, Kane County.
Black Hawk Springs, Rock Island, Rock Island County.
Diamond Mineral Spring, Grantfork, Madison County.
Magnesia Spring, Montgomery, Kane County.
Min-ni-ni-yan Spring, Bristol, Kendall County.

Perry Springs, Perry Springs, Pike County.
Red Avon Mineral Springs, Avon, Fulton County.
Sailor Springs, Sailor Springs, Clay County.
Sanicula Springs, Ottawa, Lasalle County.
Tivoli Spring, Chester, Randolph County.
Glen Flora Springs, Waukegan, Lake County.
Greenup Mineral Spring, near Greenup, Cumberland County.
Sylvan Dell Sulpho-Magnesia Spring, Galewood, Cook County.

INDIANA.

The total number of springs credited to Indiana is 13, 2 springs having been added to the list. Of these 12 report, as follows:

Elliott or Willow Valley Springs, Proctor, Martin County.
Emerald Spring, Indiana Mineral Springs, Warren County.
French Lick Springs, French Lick, Orange County.
Greenwood Sanitarium Well, Greenwood, Johnson County.
Indiana Mineral Springs, Indiana Mineral Springs, Warren County.
Kickapoo Magnetic Springs, Kickapoo, Warren County.
King's Mineral Springs, Muddyfork, Clark County.
Lodi Artesian Well, Silverwood, Fountain County.
Magnetic Mineral Springs, Terre Haute, Vigo County.
Magnetic Mineral Well, Fort Wayne, Allen County.
Spiceland Mineral Springs, Spiceland, Henry County.
West Baden Springs, West Baden, Orange County.

IOWA.

Of Iowa's 5 springs the following 4 report for 1897:

Colfax Mineral Spring, Colfax, Jasper County.
Mynster Springs, Council Bluffs, Pottawattamie County.
Ottumwa Mineral Springs, Ottumwa, Wapello County.
White Sulphur Spring, White Sulphur, Scott County.

KANSAS.

Of the 6 springs credited to Kansas the following 3 report for 1897:

Blazing's Natural Medical Spring, Manhattan, Riley County.
Geuda Mineral Springs, Geuda Springs, Cowley County.
Jewell County Lithium Spring, Montrose, Jewell County.

KENTUCKY.

The list for Kentucky remains unchanged from 1896, and of the 5 springs the following 4 report for 1897:

Anita Springs, Lagrange, Oldham County.
Bedford Springs, Bedford, Trimble County.
Blue Lick Springs, Blue Lick Springs, Nicholas County.
Crab Orchard Springs, Crab Orchard, Lincoln County.

LOUISIANA.

No reports of sales have been received from any springs in the State of Louisiana.

MAINE.

Three springs not on the list for 1896 are added for 1897, making the total 16. Of these the following 12 report:

Blue Hill Mineral Spring, Blue Hill, Hancock County.
Cold Bowling Spring, Steep Falls, Limington, York County.
Crystal Mineral Springs, Auburn, Androscoggin County.
Glenrock Springs, Greene, Androscoggin County.
Glenwood Mineral Spring, St. Albans, Somerset County.
Hartford Cold Spring, Hartford, Oxford County.
Keystone Mineral Spring, East Poland, Androscoggin County.
Paradise Spring, Brunswick, Cumberland County.
Pine Spring, Topsham, Sagadahoc County.
Pownal Spring, West Pownal, Cumberland County.
Seal Rock Springs, Saco, York County.
Underwood Spring, Falmouth Foreside, Cumberland County.

MARYLAND.

Maryland's list remains unchanged. Of the 7 springs credited to the State 6 report as follows:

Algonquin Springs, Oxen Hill, Prince George County.
Blackiston Island Diuretic Mineral Spring, Blackiston Island, St. Marys County.
Carroll Springs, Forest Glen, Montgomery County.
Chattolanee Springs, Chattolanee, Baltimore County.
Strontia Mineral Spring, Brooklandville, Baltimore County.
Tacoma Springs, Tacoma, Montgomery County.

MASSACHUSETTS.

Six springs are added to the list for Massachusetts and 2 are dropped, leaving the total at 28. Of these all but 1 report, as follows:

Ballardvale Lithia Spring, Lowell, Middlesex County.
Belmont Hill Spring, Everett, Middlesex County.
Belmont Spring, Belmont, Middlesex County.
Burnham Spring, Methuen, Essex County.
Columbia Lithia Spring, Revere, Suffolk County.
Commonwealth Mineral Spring, Waltham, Middlesex County.
Crystal Mineral Spring, Methuen, Essex County.
Chapman's Crystal Spring, Stoneham, Middlesex County.
Diamond Spring, Lawrence, Essex County.
Electric Spring, Lynn, Essex County.
Everett Crystal Spring, Everett, Middlesex County.
Farrington's Silver Spring, Milton, Norfolk County.
Geddes Mineral Spring, Marlboro, Middlesex County.
Goulding Spring, Whitman, Plymouth County.
Katahdin Spring, Lexington, Middlesex County.
Linden Mineral Spring, Linden, Middlesex County.
Massasoit Spring, Springfield, Hampden County.
Middlesex Mountain Spring, Malden, Middlesex County.
Moose Hill Spring, Swampscott, Essex County.
Myles Standish Spring, South Duxbury, Plymouth County.
Nobscot Mountain Spring, Framingham, Middlesex County.

Robbins Spring, Arlington, Middlesex County.
Shawmut Spring, West Quincy, Norfolk County.
Sheep Rock Spring, Lowell, Middlesex County.
Simpson Spring, South Easton, Bristol County.
Undine Spring, Brighton, Suffolk County.
Whittier Spring, Danvers, Essex County.

MICHIGAN.

Michigan gains 5 new springs, bringing the total up to 18, and all report. They are:

Bromo-Hygei Springs, Coldwater, Branch County.
Americanus Well, Lansing, Ingham County.
Clarke Red Cross Well, Big Rapids, Mecosta County.
Eastman Springs, Benton Harbor, Berrien County.
Excelsior Springs, Benton Harbor, Berrien County.
Magnetic Mineral Spring, Spring Lake, Ottawa County.
Medea Spring, Mount Clemens, Macomb County.
Midland Mineral Springs, Midland City, Midland County.
Moorman Springs, Ypsilanti, Washtenaw County.
Mount Clemens Sprudel Water, Mount Clemens, Macomb County.
No-che-mo Mineral Spring, Reed City, Osceola County.
Pagoda Springs, Mount Clemens, Macomb County.
Plymouth Rock Well, Plymouth, Wayne County.
Ponce de Leon Springs, Paris Township, Kent County.
Salutaris Spring, St. Clair Springs, St. Clair County.
Sterling Springs, Crystal Falls, Iron County.
Ypsilanti Mineral Spring, Ypsilanti, Washtenaw County.
Zauber Wasser Springs, Hudson, Lenawee County.

MINNESOTA.

No change is noted for Minnesota. Of the 5 springs credited to the State the following 4 report:

Indian Medical Spring, Elk River, Sherburn County.
Inglewood and Glenwood Springs, Minneapolis, Hennepin County.
Mankato Mineral Spring, near Mankato, Blue Earth County.
Trio Siloam Springs, Austin, Mower County.

MISSISSIPPI.

The list for Mississippi remains the same as for 1896. Of her 5 springs the following 4 report for 1897:

Browns Wells, Browns Wells, Copiah County.
Castalian Springs, Durant, Holmes County.
Godbold Mineral Well, Summit, Pike County.
Stafford Mineral Springs, near Vosburg, Jasper County.

MISSOURI.

Of Missouri's 9 springs 8 report for 1897. They are:

Albaqua Mineral Springs, St. Joseph, Buchanan County.
B. B. Mineral Springs, Bowling Green, Pike County.

Blue Lick Springs, Blue Lick, Saline County.
Eldorado Springs, Cedar County.
Excelsior Springs, Excelsior Springs, Clay County.
Lineville Mineral Springs, Mercer County, near Lineville, Iowa.
McAllister Springs, McAllister, Saline County.
Sweet Springs, Sweet Springs, Saline County.

MONTANA.

Only 1 of Montana's 2 springs reports sales for 1897, viz:

Lissner's Mineral Springs, Helena, Lewis and Clarke County.

NEW HAMPSHIRE.

No change is noted for New Hampshire. The 3 springs credited to the State all report in 1897, as follows:

Amherst Mineral Spring, Amherst, Hillsboro County.
Londonderry Lithia Spring, Londonderry, Rockingham County.
Pack Monadnock Lithia Spring, Temple, Hillsboro County.

NEBRASKA.

Nebraska, as usual, reports 1 spring for 1897, viz:

Victoria Mineral Springs, New Helena, Custer County.

NEW JERSEY.

As in 1896, so in 1897, both of the springs on our list for New Jersey report. They are:

Kalium Springs, Collingswood, Camden County.
Pine Grove Mineral Spring, Woodbury, Gloucester County.

NEW MEXICO.

Two springs added to the list for New Mexico bring the total up to 5, and all report for 1897:

Coyote Canyon Springs, Coyote Canyon, Bernalillo County.
Harsch's Iron Springs, Coyote Canyon, Bernalillo County.
Hudson Hot Springs, Hudson, Grant County.
Macbeth Springs, East Las Vegas.
Ojo Caliente Spring, Ojo Caliente, Taos County.

NEW YORK.

New York gains 10 springs new to the list. The total for the State is 41, and of these 38 report, as follows:

Artesian Lithia Spring, Ballston Spa, Saratoga County.
Avon Sulphur Spring, Avon, Livingston County.
A. D. Ayer Amherst Mineral Springs, near Williamsville, Erie County.
Binghamton Vichy Spring, Binghamton, Broome County.
Boonville Mineral Springs, Boonville, Oneida County.

Cayuga Water, Cayuga, Cayuga County.
Colonial Mineral Springs, West Deer Park, Suffolk County.
Crystal Rock Spring, Fairport, Monroe County.
Deep Rock Springs, Oswego, Oswego County.
Elixer Spring, Clintondale, Ulster County.
Geneva Lithia Spring, Geneva, Ontario County.
Great Bear Spring, Fulton, Oswego County.
Halcyon Spring, South Millbrook, Dutchess County.
Kirkland Springs, Franklin Iron Works, Oneida County.
Massena Springs, Massena, St. Lawrence County.
Oliphant's Mineral Spring, Oswego, Oswego County.
Rigney's Sulphur Springs, Rensselaer, Rensselaer County.
Saratoga Springs, Saratoga County:
  Champion Spring.
  Empire Spring.
  Excelsior Spring.
  Geyser Spring.
  Hathorn Spring.
  High Rock Spring.
  Lincoln Spring.
  Old Putnam Spring.
  Patterson Mineral Spring.
  Royal Spring.
  Saratoga Carlsbad Spring.
  Saratoga Kissingen Spring.
  Saratoga Star Spring.
  Saratoga Vichy Spring.
  Saratoga Victoria Spring.
  Union Spring.
Table Rock Mineral Spring, Honeoye Falls, Monroe County.
Verona Mineral Springs, Verona, Oneida County.
Victor Mineral Springs, Darien, Genesee County.
White Sulphur Springs, Richfield Springs, Otsego County.
White Sulphur Spring, Sharon Springs, Schoharie County.

NORTH CAROLINA.

Of North Carolina's 8 springs 6 report for 1897, as follows:

Ashley Bromine and Arsenic Spring, Ashe County.
Barium Springs, Barium Springs, Iredell County.
Lemon Springs, Lemon Springs, Moore County.
Park's Spring, Caswell County, near Danville, Va.
Panacea Springs, Warren County.
Thompson's Bromine Arsenic Springs, Crumpler, Ashe County.

OHIO.

The total number of springs for Ohio is increased by 2, being now 14. Of these, 12 report, as follows:

Concord Crystal Spring, Concord, Lake County.
Crum Mineral Springs, Austintown, Mahoning County.
Crystal Rock Spring, Erie County.
Devonian Mineral Spring, Lorain, Lorain County.

La Fountaine Mineral Springs, Fountain Park, Champaign County.
Magnetic and Saline Spring, Marysville, Union County.
Puritas Mineral Springs, Rockport, Cuyahoga County.
Purtlebaugh Mineral Spring, Urbana, Champaign County.
Rex Mineral Spring, New Richmond, Clermont County.
Sulphur Lick Springs, Anderson, Ross County.
Talewanda Mineral Springs, near College Corner, Preble County.

OREGON.

Of the 3 springs credited to Oregon, the following 2 report for 1897:

Siskiyou Mineral Spring, near Ashland, Jackson County.
Wilhoit Springs, Wilhoit, Clackamas County.

PENNSYLVANIA.

One spring is dropped from Pennsylvania's list, but 7 are added. The total for the State is 27. Of these, the following 25 report for 1897:

Aquatone Mineral Spring, Aquetong, Bucks County.
Black Barren Mineral Spring, Pleasant Grove, Lancaster County.
Bedford Springs, Bedford, Bedford County.
Cambridge Natural Mineral Springs, Cambridge Springs, Crawford County.
Charmian Springs, Charmian, Franklin County.
Cloverdale Lithia Springs, Newville, Cumberland County.
Cresson Springs, Cresson, Cambria County.
De Vita Mineral Springs, Cambridge Springs, Crawford County.
East Mountain Lithia Well, near Factoryville, Wyoming County.
Gettysburg Katalysine Spring, Gettysburg, Adams County.
Great Indian Spring, Glen Summit, Luzerne County.
Glen Summit Spring, Glen Summit, Luzerne County.
J. W. Lang Mineral Well, Venango, Crawford County.
Parker Mineral Spring, Gardeau, McKean County.
Pavillion Spring, Wernersville, Berks County.
Petticord Mineral Springs, Cambridge Springs, Crawford County.
Ponce de Leon Spring, Meadville, Crawford County.
Pulaski Natural Mineral Springs, Pulaski, Lawrence County.
Rennyson Tredyffrin Springs, Rennyson, Chester County.
Roscommon Springs, Wind Gap, Monroe County.
Saegertown Mineral Spring, Crawford County.
Sizer Mineral Springs, Sizerville, Cameron County.
Springboro Mineral Springs, Springboro, Crawford County.
Susquehanna County Springs, Rush, Susquehanna County.
Tuscarora Lithia Spring, McClaysville, Juniata County.

RHODE ISLAND.

One spring, new to the list, is put to the credit of Rhode Island. All 4 springs report for 1897. They are:

Gladstone Spring, Narragansett Pier, Washington County.
Holda Springs, Lymansville, Providence County.
Holly Spring, Woonsocket, Providence County.
Ochee Mineral and Medical Springs, Johnson, Providence County.

SOUTH CAROLINA.

The total for South Carolina remains at 5, as for 1896, 1 spring being added and 1 taken from the list. Four report as follows:

Bellevue Mineral Spring, Columbia, Richland County.
Chicks Springs, Chicks Springs, Greenville County.
Garretts Spring, Spartanburg, Spartanburg County.
Harris Lithia Springs, Waterloo, Laurens County.

SOUTH DAKOTA.

The 3 springs at South Dakota's one locality of our list report for 1897, viz:

Hot Springs of South Dakota, Hot Springs, Fall River County.
  Kidney Spring.
  Lakotah Springs.
  Min-ne-kahta Spring.

TENNESSEE.

Tennessee shows no change for 1896, and the 6 springs report for 1897. They are:

Dixie Mineral Spring, Knoxville, Knox County.
Estill Springs, Estill Springs, Franklin County.
Idaho Springs, St. Bethlehem, Montgomery County.
Red Boiling Springs, Red Boiling Springs, Macon County.
Rhea Springs, Rhea Springs, Rhea County.
Tate Epsom Springs, Tate Spring, Grainger County.

TEXAS.

Texas gains 2 springs, and the total for the State is now 15. Of these, the following 13 report for 1897:

Capp's Mineral Wells, Longview, Gregg County.
Dalby Springs, Dalby Springs, Bowie County.
Elkhart Mineral Wells, Elkhart, Anderson County.
Farrier Springs, Dalby Springs, Bowie County.
High Island Mineral Spring, near Galveston.
Hynson's Iron Springs, Marshall, Harrison County.
Mineral Wells, Mineral Wells, Palo Pinto County.
Montvale Springs, Marshall, Harrison County.
Overall Mineral Wells, Franklin, Robertson County.
Rosborough Springs, Marshall, Harrison County.
Sour Mineral Spring, near Luling, Caldwell County.
Tioga Mineral Wells, Grayson County.
Wootan Wells, Wootan Wells, Robertson County.

UTAH.

Of Utah's 3 springs on our list, the following 2 report:

Deseret Lithia Springs, Deseret, Millard County.
Wasatka Springs, Salt Lake City, Salt Lake County.

VERMONT.

Two springs are added to the list for Vermont, making the total 7. Of these, 6 report. They are:

Clarendon Springs, Clarendon Springs, Rutland County.
Crystal Spring, Barnet, Caledonia County.
Equinox Spring, Manchester, Bennington County.
Missisquoi Mineral Springs, Sheldon, Franklin County.
Old Sweet Spring, Hinesburg, Chittenden County.
Vermont Mineral Spring, Brookline, Windham County.

VIRGINIA.

Three springs added to Virginia's list bring the total up to 41, and of these, the following 34 report for 1897:

Ætna Lithia Springs, Roanoke, Roanoke County.
Beaufont Lithia Springs, Beaufont, Chesterfield County.
Blue Ridge Springs, Botetourt County.
Buffalo Lithia Springs, Buffalo Lithia Springs, Mecklenburg County.
Chase City Mineral Springs, Chase City, Mecklenburg County.
Colonial Springs, near Claybank Wharf, Gloucester County.
Crockett Arsenic Lithia Spring, Shawsville, Montgomery County.
Farmville Lithia Springs, Cumberland County, near Farmville, Prince Edward County.
Harris Anti-Dyspeptic and Tonic Spring, Burkeville, Nottoway County.
Healing Springs, Healing Springs, Bath County.
Hunter's Pulaski Alum Springs, Walkers Creek, Pulaski County.
Iron Lithia Springs, Tip Top, Tazewell County.
Jefferson Park Springs, near Charlottesville, Albemarle County.
Jordan White Sulphur Spring, Stephenson, Frederick County.
Lake Como Lithia Spring, Henrico County.
Magee's Chlorinated Lithia Spring, Clarksville, Mecklenburg County.
Massanetta Springs, Harrisonburg, Rockingham County.
Nye Lithia Springs, Wytheville, Wythe County.
Old Dominion Lithia Springs, Clarksville, Mecklenburg County.
Osceola Springs, Pleasant Valley, Rockingham County.
Otterburn Lithia and Magnesia Springs, Amelia, Amelia County.
Pæonian Springs, Loudoun County.
Rawley Springs, near Harrisonburg, Rockingham County.
Roanoke Red Sulphur Springs, near Salem, Roanoke County.
Rockbridge Alum Springs, Alum Springs, Rockbridge County.
Rockingham Virginia Springs, McGaheysville Station, Rockingham County.
Seawright Magnesian Lithia Spring, Staunton, Augusta County.
Seven Springs, near Glade Spring, Washington County.
Stribling Springs, Stribling Springs, Augusta County.
Swineford's Arsenic Lithia Springs, Osceola, Washington County.
Virginia Magnesian Alkaline Springs, near Staunton, Augusta County.
Virginia Waukesha Lithia Springs, Staunton, Augusta County.
Wallawhatoola Alum Springs, near Millboro Spring, Bath County.
Wolf Trap Lithia Springs, Wolf Trap, Halifax County.

WASHINGTON.

The 3 springs credited to the State of Washington all report for 1897. They are:

Cascade Springs, near Cascades, Skamania County.
Medical Lake, Medical Lake, Spokane County.
Yakima Soda Springs, near North Yakima, Yakima County.

WEST VIRGINIA.

One new spring increases West Virginia's list to 7, and all report for 1897. They are:

Capon Springs, Capon Springs, Hampshire County.
Greenbrier White Sulphur Springs, White Sulphur Station, Greenbrier County.
Irondale Spring, Independence, Preston County.
Red Sulphur Springs, Red Sulphur Springs, Monroe County.
Salt Sulphur Springs, Salt Sulphur Springs, Monroe County.
Triplet Well, Calf Creek, Grant District, Pleasants County.
Webster Springs, Addison, Webster County.

WISCONSIN.

The total for Wisconsin is 32 springs, 3 having been added to the list of 1896. Of these, the following 28 report for 1897:

Aurelian Spring, Palmyra Springs, Jefferson County.
Bay City Spring, Ashland, Ashland County.
Bethania Mineral Spring, Osceola, Polk County.
Chippewa Spring, Chippewa Falls, Chippewa County.
Castalia Springs, Wauwatosa, Milwaukee County.
Darlington Mineral Springs, Darlington, Lafayette County.
Fort Crawford Springs, Prairie du Chien, Crawford County.
Lebens Wasser, Green Bay, Brown County.
Nee-Ska-Ra Mineral Spring, Wauwatosa, Milwaukee County.
Rainbow Mineral Spring, Wautoma, Waushara County.
Salvator Springs, Green Bay, Brown County.
Sheboygan Mineral Spring, Sheboygan, Sheboygan County.
Silver Sand Spring, Milwaukee, Milwaukee County.
Solon Springs, Upper St. Croix Lake, Douglas County.
Sparkling Spring, Wauwatosa, Milwaukee County.
St. John Mineral Spring, Green Bay, Brown County.
Waukesha Springs, Waukesha County:
    Acme Spring.
    Almanaris Springs.
    Arcadian Spring.
    Bethesda Mineral Spring.
    Fountain Spring.
    Henk Mineral Spring.
    Horeb Spring.
    Minniska Mineral Spring.
    Siloam Spring.
    Silurian Mineral Spring.
    Sotarian Spring.
    White Rock Mineral Spring.

Summary of reports of mineral springs for 1897.

States and Territories.	Springs reporting.	Springs not reporting.	Total used commercially.
NORTH ATLANTIC STATES.			
Maine	12	4	16
New Hampshire	3	0	3
Vermont	6	1	7
Massachusetts	27	1	28
Rhode Island	4	0	4
Connecticut	8	4	12
New York	38	3	41
New Jersey	2	0	2
Pennsylvania	25	2	27
SOUTH ATLANTIC STATES.			
Delaware	0	0	0
Maryland	6	1	7
District of Columbia	1	0	1
Virginia	34	7	41
West Virginia	7	0	7
North Carolina	6	2	8
South Carolina	4	1	5
Georgia	7	1	8
Florida	3	0	3
SOUTH CENTRAL STATES.			
Kentucky	4	1	5
Tennessee	6	0	6
Alabama	4	0	4
Mississippi	4	1	5
Louisiana	0	1	1
Texas	13	2	15
Indian Territory	0	0	0
Arkansas	5	2	7
Oklahoma	0	0	0
NORTH CENTRAL STATES.			
Ohio	12	2	14
Indiana	12	1	13
Illinois	13	4	17
Michigan	18	0	18
Wisconsin	28	4	32
Minnesota	4	1	5
Iowa	4	1	5
Missouri	8	1	9

Summary of reports of mineral springs for 1897—Continued.

States and Territories.	Springs reporting.	Springs not reporting.	Total used commercially.
NORTH CENTRAL STATES—continued.			
North Dakota	0	0	0
South Dakota	1	0	1
Nebraska	1	0	1
Kansas	3	3	6
WESTERN STATES AND TERRITORIES.			
Alaska	0	0	0
Wyoming	0	0	0
Montana	1	1	2
Colorado	10	0	10
New Mexico	5	0	5
Arizona	0	0	0
Utah	2	1	3
Nevada	0	0	0
Idaho	1	0	1
Washington	3	0	3
Oregon	2	1	3
California	24	6	30
Total	381	60	441

IMPORTS AND EXPROTS.

Prior to 1884 the Treasury Department did not distinguish natural mineral waters from those that were artificial; since 1883 the distinction has been made, but the artificial waters have not been classified according to the receptacles in which they have been imported. The importation is shown in the two tables following, with a table of exports appended.

Mineral waters imported and entered for consumption in the United States, 1867 to 1883, inclusive.

Fiscal year ended June 30—	In bottles of 1 quart or less.		In bottles in excess of 1 quart.	
	Quantity.	Value.	Quantity.	Value.
	Bottles.		*Quarts.*	
1867	370,610	$24,913	3,792	$360
1868	241,702	18,438	22,819	2,052
1869	344,691	25,635	9,739	802
1870	433,212	30,680	18,025	1,743
1871	470,947	34,604	2,320	174
1872	892,913	67,951	....	....
1873	35,508	2,326	....	....
1874	7,238	691	....	....
1875	4,174	471	....	....
1876	25,758	1,899	....	....
1877	12,965	1,328	....	....
1878	8,229	815	....	....
1879	28,440	2,352	....	....
1880	207,554	19,731	....	....
1881	150,326	11,850	....	....
1882	152,277	17,010	....	....
1883	88,497	7,054	....	....

Fiscal year ended June 30—	Not in bottles.		All not artificial.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Gallons.		*Gallons.*		
1867	....	$137	....	....	$25,410
1868	554	104	....	....	20,594
1869	1,042	245	....	....	26,682
1870	2,063	508	....	....	32,931
1871	1,336	141	....	....	34,919
1872	639	116	....	....	68,067
1873	355	75	394,423	$98,151	100,552
1874	95	16	199,035	79,789	80,496
1875	5	2	395,956	101,640	102,113
1876	....	....	447,646	134,889	136,788
1877	....	22	520,751	167,458	168,808
1878	....	....	883,674	350,912	351,727
1879	3	4	798,107	282,153	284,509
1880	....	....	927,759	285,798	305,529
1881	55	26	1,225,462	383,616	395,492
1882	....	....	1,542,905	410,105	427,115
1883	....	....	1,714,085	441,439	448,493

Imports for years 1884 to 1897.

Year ended—	Artificial mineral waters.		Natural mineral waters.	
	Gallons.	Value.	Gallons.	Value.
June 30—				
1884	29,366	$4,591	1,505,298	$362,651
1885	7,972	2,157	1,660,072	397,875
Dec. 31—				
1886	62,464	16,815	1,618,960	354,242
1887	13,885	4,851	1,915,511	385,906
1888	12,752	4,411	1,716,461	341,695
1889	36,494	8,771	1,558,968	368,661
1890	22,328	7,133	2,322,008	433,281
1891	26,700	8,700	2,019,833	392,894
1892	16,052	9,089	2,266,123	497,660
1893	6,086	2,992	2,321,081	506,866
1894	7,753	3,047	1,891,964	417,500
1895	101,115	19,151	2,104,811	506,384
1896	51,108	11,739	2,273,393	551,097
1897			[a] 2,942,200	[a] 501,684

[a] Including artificial.

Exports of natural mineral waters of domestic production from the United States.

Fiscal year ended June 30—	Value.
1875	$162
1876	80
1879	1,529
1880	1,486
1881	$1,029
1882	421
1883	[a] 459

[a] None reported since 1883.

MINERAL RESOURCES OF HAWAII.

The recent acquisition of the Hawaiian (also called Sandwich) Islands, causing them to become an integral part of the United States, lends renewed interest to this remarkable group, and renders appropriate a brief account of their minerals and certain features bearing upon this phase of their resources. As introductory to this a few general observations are appropriate.

History.—Although known and visited by the earlier navigators since their discovery in 1549 by the Spaniards under Gaetano, the Hawaiian Islands attracted little attention from the outside world until more carefully examined and reported upon by Captain Cook in his memorable visits of 1778 and 1779. This great navigator was much impressed by their importance, and his reports awakened attention, but not until the advent of the American missionaries in 1820 and subsequently did the wonderful fertility and possibilities of these islands begin to be fully recognized. Even then there was little development, because there was practically no outside market for their products and the local requirements were so simple and limited, while occasional visits of traders and whalers gave little stimulus. But with the settling and rapid development of the Pacific coast of the United States an outlet for the exportation of tropical fruits, etc., and later of sugar, was opened, and from that time on progress has been marked and constant.

American influence has predominated during the last seventy or eighty years, though English and other settlers were also present and helped to effect the change in the habits, pursuits, and condition of the aboriginal inhabitants. When first known to Europeans the islands were under a sort of feudal and hieratic system or systems, which were consolidated into a single monarchy by the conquests of Kamehameha I. Later the Government became a liberal, limited monarchy, with a constitution, and having in part a representative character. This was overthrown by the revolution of 1892. During the Administration of President Harrison a treaty annexing the islands to the United States was negotiated, but it was withdrawn by President Cleveland. On June 15, 1898, the Newlands joint resolution of annexation was passed by the House of Representatives, and by the Senate July 6 following. The signature by President McKinley, July 7, and the formal raising of the American flag in August, completed the annexation.

Geography.—The Hawaiian Islands are in latitude 18° 51′ to 22° 50′ N., and longitude 154° 50′ to 161° 40′ W., and are about 2,700 miles southwest of San Francisco. There are twelve islands in the group, of which nine are inhabited, and three are barren rocks. The total area is 6,677 square miles. Hawaii proper, the largest island, contains about 4,000 square miles. Oahu is the most important commercially, having the fine harbor of Honolulu and Pearl Harbor. The other principal islands are Maui, Molokai, and Kaui.

The interior of the larger islands is mountainous, with elevations ranging up to the 13,805 feet of Mauna Kea, on Hawaii. There are fertile valleys and plateaus of varying elevation, rainfall, and temperature, and the lowlands bordering the ocean.

Population.—The estimate of 400,000 inhabitants given by Captain Cook a century ago was doubtless excessive. In 1820 there were supposed to be about 130,000 natives, since which time they have been steadily diminishing. Originally a fine, strong, brave, but too docile and hospitable a race, they have succumbed to the mistaken efforts of their well-meaning civilizers, the natural result of radical and sudden changes of diet, clothing, habits, etc., upon a physique evolved during ages of adjustment to environment; while the diseases and vices introduced by traders and sailors have had a further deteriorating effect, so that in 1890 only 34,436 of the native stock remained, the fact that the native Hawaiians are still dying off being indicated by the decrease of 5,578 between 1884 and 1890. In the latter year the total population was 89,990; it is now larger, immigration having more than offset native losses. There were 15,301 Chinese and 12,369 Japanese on the islands in 1890, which numbers have been increased. No fewer than 15,191 Portuguese had arrived in the islands by 1895, nearly all of whom were "assisted" immigrants from the Azores. At present there are some 7,000 Americans, British, Germans, and Norwegians there, of whom about 2,200 are of island birth, and somewhat over 2,000 were born in the United States. It is expected that the number of Americans and of desirable European settlers will be considerably increased by immigration. It is also anticipated that the material prosperity of the islands will still further improve under the new and stable control.

Agriculture in relation to minerals.—The agricultural capacity of the islands far overshadows the mineral, strictly speaking. Yet it is owing to the peculiar mineral constituents of the soils, together with the stored accumulations of organic matter and in connection with a favoring climate as regards temperature, sunlight, dryness or humidity, and distribution of rainfall, that the adaptability to certain crops, especially the sugar cane, coffee, tropical and semitropical fruits, vegetables, and nuts must be ascribed. The mineral resources of first importance are therefore the soils, as the basis for agricultural prosperity.

Since thus far attention has mainly and naturally been directed toward the development of agriculture, the efforts and opportunities to utilize and exploit the mineral resources other than the soils themselves have been comparatively slight. Nor is it to be anticipated that the useful mineral products will be of great importance relatively, being limited, both in kind and in quantity. The actual number of mineral species identified is quite large, corresponding to those of similar volcanic areas, but most of them are mineralogical specimens merely, rather than available for commercial purposes. Still, it must not be understood that the mineral wealth of Hawaii is wholly insignificant. On the contrary, there is an apparent field for a considerable development. The scientific study of the group has mostly been turned toward the physical geography, phenomena of vulcanism, coral growth, and latterly the chemical examination of the soils, the mineralogical interest being subsidiary.

Geology.—The core and mass of the islands consists of volcanic rocks built up from the ocean floor in comparatively recent geologic times, though at long intervals, as measured by years or centuries. These rocks range from basalt to trachyte, forming a complete series, from the most basic to the acidic, but consisting almost wholly of the more basic members, acidic rocks being much less occurrent. The proportion of the basic rocks is so large that one authority says: "Our lavas are strictly basalts." The two main classes of phonolites and graystones are, however, recognized with the usual intermediate species, varieties, and shades of gradation. Part of the rock masses are quite fresh, part much altered by chemical action and weathering. As the volcanoes, ancient and extinct to the recent and active Kilauea and Mauna Loa, all rise from the deep-sea bottom to in some cases great elevations above the sea surface, they are the most notable examples in point of magnitude and existing interest known. The craters are of both the primary and the lateral-cone types, and some of the older ones are not now recognizable, owing to weathering, denudation, and filling. Parts of ancient empty volcano throats have been exposed by caving.

Besides the predominating basalt of the eruptive rocks there are heavy fringing and barrier coral reefs, some of which have been elevated far above sea level, and in disintegrating and then compacting a calcareous sandstone has been formed, in addition to the coral limestone of the reefs in place. There are no true fossiliferous strata, but fossil shells and corals of recent species are found embedded in some of the volcanic tufas.

Mineralogy.—According to Mr. S. B. Dole some of the minerals noticed are sulphur, pyrite, common salt, sal ammoniac, limonite, quartz, augite, chrysolite, garnet, labradorite, feldspar, gypsum, soda-alum, copperas, glauber salt (sodium sulphate), niter, and calcite. The Hawaiian volcanoes have been natural laboratories, working on an almost unprecedented scale, with the strong decomposing agency of acid steam, high temperature, rainfall, and perhaps sea infiltration, so that secondary decomposition products are numerous and common. Many of the minerals identified have no economic significance, while others occur too sparsely to be profitably utilized. As at other volcanic localities and island resorts much frequented by travelers and health seekers, there is a considerable trade in specimens and curiosities of the two extreme types of products, the volcanic and the marine. These consist in minerals and fantastic lava forms from the craters and corals and shells from the shores and sea.

The geological conditions are against the occurrence of deposits of ores of the precious and other heavy metals, and, of course, preclude the formation of coal beds.

Soils.—These are derived from the volcanic lavas. According to Prof. Walter Maxwell, director and chief chemist of the Hawaiian experiment station,[1] the lavas are (1) those which have been discharged from craters, flowing and cooling into rocks having the composition of normal basalts. Others (2), originally of the same composition, have undergone such alteration that they now compose masses having a radically different composition and color. Professor Maxwell's classification is as follows:

1. Dark-red soils, formed by the simple weathering of normal lavas, in climatic conditions of great heat and dryness.
2. Yellow and light-red soils, derived from lavas which underwent great alteration, under the action of steam and sulphurous vapors, at the time of or after emission from the craters.
3. Sedimentary soils, derived from the decomposition of lavas at higher altitudes, and removal and deposition by rainfall at lower levels.

The color is an indication of the amount and condition of the iron present, and is also affected by carbonaceous matters. In general, the dark-red and sedimentary soils are distinguished by a greater and more permanent fertility than the yellow or light-red soils.

Sulphur.—The craters and upper slopes of the volcanoes are, or have been, vast solfataras, of which that of Kilauea is now the most notable. Numberless fumaroles or pipes and fissures of varying size extend from the heated interior to the surface, affording vents for sulphurous vapors. About them the surface is white with deposits of sulphur, and upon their sides and in places below the surface masses of the pure mineral are crystallized out. The quantity is so marked that one locality at Kilauea is known as the "sulphur banks," though this is but one of many remarkable occurrences.

Pyrite occurs as a secondary rock constituent, but not in segregated masses or veins in sufficient quantity to form a basis for acid making.

The water condensed from the steam and vapors of the fumaroles is charged with sulphuric acid, samples running as high as 5 per cent. It is not altogether inconceivable that some utilization might in future be discovered for the immense quantity of mineral acid constantly escaping in this dilute form.

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[1] Lavas and Soils of the Hawaiian Islands, 1898.

Gypsum.—Very large deposits of this mineral occur, some of it almost pure, as shown by the following partial analysis: CaO, 43.4 per cent; SO_3, 44.73 per cent; SiO_2, 4 per cent; Fe_2O_3, 0.7 per cent; MgO, 0.5 per cent. This is another substance which might be utilized, as land plaster if not as plaster of paris, though the small content of iron in the analysis just quoted (from Professor Maxwell) shows it to be suitable for making a very clean plaster of paris.

Alum.—The mineral of the so-called alum deposits is a mixture of the sulphates of the alkalies, iron, and alumina, with an excess of sulphuric acid. A sample analyzed as follows: Al_2O_3, 26.2 per cent; Fe_2O_3, 12.3 per cent; SO_3, 45.6 per cent, with small quantities of CaO, MgO, K_2O, Na_2O, and SiO_2. This occurs in large quantity and could be purified for commercial use.

Copperas (iron sulphate) is formed by the action of sulphurous vapors and waters upon the ferruginous basalts. It is only of mineralogical interest in this connection.

Glauber salt is similarly produced, probably from the soda liberated in the decomposition of the soda feldspars of the rocks; hardly from the salt of sea water, since free chlorine is not detected.

Sal-ammoniac (ammonium chloride) occurs as an efflorescence.

Mineral paints.—Red ocher (hematite and laterite) and yellow ocher (limonite) of vivid hues are abundant, as is also brown hematite. These are decomposition products derived by oxidation from the iron of the volcanic rocks, and are found in large pockets and in layers covering the surface of altered rock masses and along the jointing planes of the blocks. A sample of red ocher gave Fe_2O_3, 44.5 per cent; SiO_2, 32.5 per cent; Al_2O_3, 18.1 per cent, with moisture and small percentages of CaO, MgO, K_2O, Na_2O, and S. The yellow ocher consists in large proportion of silica; when burned it becomes pink or red. The quantity available and the good color of these ochers are such that attempts have been made to establish an export trade in them, but manufacturers of mineral paints in the United States are influenced by the accessibility of similar ochers nearer points of consumption. Their excellence and the results to be obtained by proper selection, grinding, burning, or mixing to produce different shades, should lead to further experiment to obtain for them something more than a restricted local utilization.

Some of the kaolinized rock, from which the iron has been leached out, forms a white clay, which might be used, as in other localities, for whitewashing, for which purpose a natural free lime, also an alteration product, is also obtainable.

Building stone, etc.—The climatic conditions and mode of life of the inhabitants do not call for much construction in stone, though there is an abundance of available material, only a little of which is utilized.

The coral limestone, calcareous and siliceous sandstones, primary eruptive rocks of fair cleavage and tufa afford a considerable variety from which to choose, but wooden construction is more common. Road material, stone for fences, jetties, fillings, etc., are also at hand. All these, together with the excellent clays for brick and tile making, lime and building sand, have but local application. The lime is obtainable by burning the coral limestone and shells.

Kaolin.—Pockets of large size and sometimes very pure material have been found. This mineral results from the decomposition of the rock-constituent minerals, especially feldspars, the silica and alumina separated out being recombined. The scale upon which the rock alteration has gone on warrants the assumption that workable deposits of kaolin may be numerous.

Pumice.—The froth and scoriæ at the surface of cooling lava flows yield a sort of pumice, serviceable either as a powder after crushing or when broken into blocks of convenient size. The filaments blown by the winds from the surface of molten lava, called "Pele's hair," are interesting specimens, corresponding in mode of formation to the artificial mineral wool produced by steam jets acting upon iron slag, which itself is analogous to lava.

Obsidian (volcanic glass) is noted merely as a curiosity.

Salt.—An industry of some local importance is the gathering of sea salt from accumulations formed by the natural concentration and evaporation of sea water, while the configuration of the shores in places, with suitable inlets and lagoons, aided by the strong solar evaporation, favors the artificial production of this commodity.

Nacre, or mother-of-pearl, occurs, and with other ornamental shells and corals forms pretty specimens.

Pearls have been found, but a productive industry of commercial importance remains to be established.

In conclusion, it may be said that the most important and promising mineral products of the Hawaiian Islands are the sulphur, gypsum, alum, mineral-paint ochers, all of which occur in large quantities and of good quality, and common salt, which latter is producible according to the demand. Besides these, some of the other substances already noted or yet to be found may come into commerce to an extent not now understood. At least there is much encouragement for further exploration and experiment in the finding, working, preparing, and marketing of the useful minerals of Hawaii.

MEMORANDUM ON THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS.

By George F. Becker.

INTRODUCTION.

This brief memorandum probably covers all the main discoveries in the geology of the Philippines which are of economic interest. It is drawn up from data recorded in the Spanish Mining Bureau (Inspeccion de Minas) but not published, manuscript mine reports by the late William Ashburner, verbal information obtained in Manila, and various technical publications of Semper, Santos, Roth, Drasche, Abella, and others.

Only about a score of the islands are known to contain deposits of valuable minerals. These are arranged below in the order of their latitude, to give an idea of their geographical distribution and to facilitate finding the islands on the map. The latitude of the northern end of each is taken as that of the island. The character of the valuable minerals stated in the table will afford a general notion of the resources of the islands.

Mineral-bearing islands and their resources.

Island.	Latitude (north end)		Character of mineral resources.
	°	′	
Luzon	18	40	Coal, gold, copper, lead, iron, sulphur, marble, kaolin.
Catanduanes	14	8	Gold.
Marinduque	13	34	Lead, silver.
Mindoro	13	32	Coal, gold, copper.
Carraray	13	21	Coal.
Batan	13	19	Do.
Rapu-Rapu	13	15	Do.
Masbate	12	37	Coal, copper.
Romblon	12	37	Marble.
Sámar	12	36	Coal, gold.

Mineral-bearing islands and their resources—Continued.

Island.	Latitude (north end).		Character of mineral resources.
	°	′	
Sibuyan	12	30	Gold.
Semirara	12	7	Coal.
Panay	11	56	Coal, oil, gas, gold, copper, iron, mercury (?).
Biliran	11	43	Sulphur.
Leyte	11	35	Coal, oil, mercury (?).
Cebú	11	17	Coal, oil, gas, gold, lead, silver, iron.
Negros	11		Coal.
Bohol	10	10	Gold.
Panaon	10	10	Do.
Mindanao	9	50	Coal, gold, copper, platinum.
Sulú Archipelago	6	30	Pearls.

The distribution of each mineral or metal may now be sketched in somewhat greater detail. In many cases the information given in this abstract is exhaustive, so far as the available material is concerned. The coal fields of Cebú, however, have been studied in some detail by Mr. Abella, and in a few other instances more extended information has been condensed for the present purpose.

COAL.

So far as is definitely known, the coal of the Philippine Islands is all of Tertiary age, and might better be characterized as a highly carbonized lignite. It is analagous to the Japanese coal and to that of Washington, but not to the Welsh or Pennsylvania coals. Such lignites usually contain considerable combined water (8 to 18 per cent) and bear transportation ill. They are also apt to contain much sulphur, as iron pyrite, rendering them subject to spontaneous combustion and injurious to boiler plates. Nevertheless, when pyritous seams are avoided and the lignite is properly handled it forms a valuable fuel, especially for local consumption. In these islands it would appear that the native coal might supplant English or Australian coal for most purposes. Lignite is widely distributed in the archipelago; some of the seams are of excellent width, and the quality of certain of them is high for fue in this class.

Coal exists in various provinces of the island of Luzon (Abra, Camarines, Bataan, Sorsogon). The finest beds thus far discovered appear to be those in the small island of Batan, lying to the east of the southern portion of Luzon, in latitude 13° 19′. These seams vary from 2 feet 6 inches to 14 feet 8 inches in thickness. Analyses have been made in the laboratory of the Inspeccion de Minas, and the mean of seven analyses gives the following composition:

Analysis of coal from Batan, one of the Philippine Islands.

Constituent.	Per cent.
Water	13.52
Volatile matter	37.46
Fixed carbon	44.46
Ash	4.56
Total	100

One pound of this coal will convert 6.25 pounds of water at 40° C. into steam at 100° C. The heating effect is about three-fourths that of Cardiff coal. The same beds are known to exist in other small adjacent islands, Carraray and Rapu-Rapu. A number of concessions for coal mining have also been granted on the main island of Luzon just south of Batan, at the town Bacon. No doubt the beds here are either identical or at least closely associated with the coal seams in the little islands.

The coal field of southern Luzon is said to extend across the Strait of San Bernardino into the northern portion of Sámar. Here coal is reported at half a dozen localities, but I have been able to ascertain no details as to the thickness or quality.

In Mindoro there are large deposits of coal in the extreme southern portion (Bulacao) and on the small adjacent island of Semirara. This fuel is said to be similar to that of Batan.

The islands of Masbate and Panay contain coal, the deposits of which thus far discovered do not seem of much importance. Specimens from the southwestern portion of Leyte, analyzed in the laboratory of the Inspeccion de Minas, are of remarkably high quality, but nothing definite about the deposit is known to me.

The first discovery of coal in the archipelago was made in the island of Cebú in 1827. Since then lignitic beds have been found on the island at a great variety of points. The most important croppings are on the eastern slope within some 15 or 20 miles of the capital, also named Cebú. Though a considerable amount of coal has been extracted here, the industry has not been a profitable one hitherto. This is, at least in part, due to crude methods of transportation. It is said, however, that the seams are often badly faulted.

At Uling, about 10 miles west of the capital, the seams reach a maximum thickness of 15½ feet. Ten analyses of Cebú coal are at my disposal. They indicate a fuel with about two-thirds the calorific effect of Cardiff coal, and with only about 4 per cent ash. Large quantities of the coal might, I suspect, contain a higher percentage of ash.

The island of Negros is nearly parallel with Cebú, and appears to be of similar geological constitution, but it has been little explored and little of it seems to have been reduced to subjection by the Spaniards. There are known to be deposits of coal at Calatrava, on the east coast of Negros, and it is believed that they are of important extent. In the great island of Mindanao coal is known to occur at eight different localities, but no detailed examinations of any kind appear to have been made. Seven of these localities are on the east coast of Mindanao and the adjacent small islands. They indicate the presence of lignite from one end of the coast to the other. The eighth locality is in the western province called Zamboanga, on the Gulf of Sibuguey.

PETROLEUM.

In the island of Cebú petroleum has been found associated with coal at Toledo, on the west coast, where a concession has been granted. It is also reported from Asturias, to the north of Toledo, on the same coast, and from Alegria, to the south. Natural gas is said to exist in the Cebú coal fields. On Panay, too, oil is reported at Janinay, in the province of Iloilo, and gas is reported from the same island. Petroleum highly charged with paraffin is also found on Leyte, at a point about 4 miles from Villaba, a town on the west coast.

GOLD.

Gold is found at a vast number of localities in the archipelago, from northern Luzon to central Mindanao. In most cases the gold is detrital, and is found either in existing water courses or in stream deposits now deserted by the current. These last are called "aluviones" by the Spaniards. It is said that in Mindanao some of the gravels are in an elevated position and adapted to hydraulic mining. There are no data at hand which indicate decisively the value of any of the placers. They are washed by natives, largely with cocoanut shells for pans, though the batea is also in use.

In the province of Abra, at the northern end of Luzon, there are placers, and the gravel of the river Abra is auriferous. In Lepanto there are gold-quartz veins as well as gravels. Gold is obtained in this province close to the copper mines. In Benguet the gravels of the river Agno carry gold. There is also gold in the province of Bontoc and in Nueva Écija. The most important of the auriferous provinces is Camarines Norte. Here the townships of Mambulao, Paracale, and Labo are especially well known as gold-producing localities. Mr. Drasche, a well-known German geologist, says that there were 700 natives at work on the rich quartz veins of this place at the time of his visit about twenty-five years ago. At Paracale there are parallel quartz veins in granite, one of which is 20 feet in width and contains a chute in which the ore is said to assay 38 ounces of gold to the ton. One may suspect that this assay hardly represented an average sample. Besides the localities mentioned, many others in this province have been worked by the natives.

The islands of Mindoro, Catanduanes, Sibuyan, Sámar, Panay, Cebú, and Bohol are reported to contain gold, but no exact data are accessible.

At the south end of the small island of Panaon, which is just to the south of Leyte, there are gold-quartz veins, one of which has been worked to some extent. It is 6 feet in thickness and has yielded from $6 to $7 per ton.

In the island of Mindanao there are two known gold-bearing districts. One of these is in the province of Surigao, where Placer and other townships show gravels and veins. The second district is in the province of Misamis. Near the settlement of Imponan, on the Gulf of Macajalar, there are said to be many square kilometers of gravels carrying large quantities of gold with which is associated platinum. The product of this district was estimated some years since at 150 ounces per month, all extracted by natives with bateas or cocoanut-shell dishes.

COPPER.

Copper ores are reported from a great number of localities in the Philippines. They are said to occur in the following islands: Luzon (provinces of Lepanto, Benguet, and Camarines), Mindoro, Capul,[1] Masbate, Panay (province of Antique), and Mindanao (province of Surigao). Many of these occurrences are probably unimportant. The great island of Mindanao, being practically unexplored, is full of possibilities, but as yet no important copper deposit is known to exist there. An attempt was made to work the deposit in Masbate, but no success seems to have been attained. On the other hand, northern Luzon contains a copper region which is unquestionably valuable. The best-known portion of this region lies about Mount Datá, a peak given as "2,500 meters?" in height, lying in latitude 16° 53′, longitude 120° 58′ east of Greenwich, or 124° 38′ east of Madrid. The range of which Datá forms one peak trends due north to Cape Lacay-Lacay, and forms a boundary for all the provinces infringing upon it.

Datá itself lies in the province of Lepanto. In this range copper ore has been smelted by the natives from time immemorial and before Magellan discovered the Philippines. The process is a complicated one, based on the same principles as the method of smelting sulpho-salts of this metal in Europe and America. It consists in alternate partial roasting and reduction to "matte" and eventually to black copper. It is generally believed that this process must have been introduced from China or Japan. It is practiced only by one peculiar tribe of natives, the Igorrotes, who are remarkable in many ways.

Vague reports and the routes by which copper smelted by natives comes to market indicate that there are copper mines in various portions of the Cordillera Central, but the only deposits which have been examined with any care are those at Mancayan (about 5 miles west of

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[1] I am unable to find this island, which probably is a very small one.

Mount Datá) and two or three other localities within a few miles of Mancayan. The deposits of Mancayan are described as veins of rich ore, reaching 7 meters in width and arranged in groups. Mean assays are said to show over 16 per cent of copper, mainly as tetrahedrite and allied ores. The gangue is quartz. The country rock is described as a large quartzite lens embedded in a great mass of trachyte. An attempt has been made by white men to work these deposits, but with no considerable success. The failure does not seem to have been due to the quality or quantity of ore found.

LEAD AND SILVER.

A lead mine has been partially developed near the town of Cebú, on the island of the same name.

The most important deposit of argentiferous galena is said to be at Torrijos, on the small island of Marinduque (latitude 13° 34′). A metric ton, or 1,000 kilograms, is said to contain 96 grams of silver, 6 grams of gold, and 565.5 kilograms of lead.

In Camarines, a province of Luzon, lead ores occur, but are worked only for the gold they contain.

IRON.

There is iron ore in abundance in Luzon, Caraballo,[1] Cebú, Panay, and doubtless in other islands. In Luzon it is found in the provinces of Laguna, Pampanga, and Camarines Norte, but principally in Bulacan. The finest deposits are in the last-named province, near a small settlement named Camachin, which lies in latitude 15° 7′ and longitude 124° 47′ east of Madrid. A small industry exists here, wrought iron being produced in a sort of bloomery and manufactured into plowshares. The process has not been described in detail, so far as I know. It would appear that charcoal pig iron might be produced to some advantage in this region. The lignites of the archipelago are probably unsuitable for iron blast furnaces.

QUICKSILVER.

Rumors of the occurrence of this metal in Panay and Leyte have failed of verification. Accidental losses of this metal by prospectors or surveyors sometimes lead to reports of the discovery of deposits, and ochers are not seldom mistaken for impure cinnabar.

NONMETALLIC SUBSTANCES.

Sulphur deposits abound about active and extinct volcanoes in the Philippines. In Luzon the principal sulphur deposits are at Daclan, in the province of Benguet, and at Colasi, in Camarines. The finest deposit in the archipelago is said to be on the little island of Biliran, which lies to the northwest of Leyte.

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[1] I have not found this island on the map.

Marble of fine quality occurs on the small island of Romblon (latitude 12° 37′). It is much employed in churches in Manila for baptismal fonts and other purposes. Marbles are also quarried at Montalban in the province of Manila, and at Binangonan in the province of Marong.

There are concessions for mining kaolin at Los Baños, in Laguna Province.

Pearl fisheries exist in the Sulú Archipelago, and are said to form an important source of wealth.

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